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Donna Creek Forestry/Biodiversity Project: Cavity Nests 1995 and 1996

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EXECUTIVE SUMMARY

The Donna Creek Forestry/Biodiversity Project was initiated in 1990 to develop and test alternative timber-harvesting techniques, particularly 3-m high-cut stumps (stubs) at densities of 5-10 stubs/ha, and 0.25-ha tree islands with one island for every 8 ha. Both features were designed to benefit tree-cavity-using birds and mammals. This report documents the cavity nests within and near the 3 experimental cutblocks at Donna Creek in 1995 and 1996, after timber harvesting in 1991 and 1992.

There were 15 cavity nests within the experimental blocks in 1995, and 16 cavity nests in 1996. An additional 16 cavity nests of 4 species were found over the two years in other areas including the **CC** units, **OG** areas, and the continuous forest at the outer perimeters of cutblocks. Four cavity-nesting bird species were found commonly in the experimental cutblocks, with between 5 and 9 nests found for black-backed woodpeckers, three-toed woodpeckers, mountain bluebirds, and tree swallows. Three-toed woodpeckers nested commonly in the study area, but less commonly within the tree islands and stubs in the blocks.

Based on the stems used by the cavity-nesting birds, stubs identified for retention should be as large as possible, preferably over 27-cm DBH, and spruce and balsam trees should be selected over lodgepole pine. However, stubs to be used for feeding by woodpeckers are also important. These stubs can be any size, but larger diameter and spruce and balsam stubs are again preferred.

The mitigation values of stubs and tree islands to cavity-nesting birds in clearcut cutblocks is indisputable: without either stubs or tree islands, there were no cavity nests in clearcuts. Since clearcutting has largely replaced wildfire as the main agent of forest renewal, stubs and tree islands in cutblocks can effectively mitigate the effects of clearcutting for some species that would otherwise be common in post-wildfire stands,. Stubs densities of 5-10 stubs/ha in combination with tree islands of 0.25 ha can mitigate the effects of clearcutting on black-backed woodpeckers, since they nested in stubs and tree islands throughout the blocks, but will not generally be sufficient for three-toed woodpeckers, except for tree islands and stubs within about 50 m of continuous forest. Stubs and/or tree islands can mitigate the effects of clearcutting for tree swallows, mountain bluebirds and American kestrels in clearcuts.

Stubs at densities of 5-10 stubs/ha and 0.25-ha tree islands are not effective mitigation methods for the effects of clearcutting on boreal chickadees, red-breasted nuthatches,

brown creepers or winter wrens that typically do not use early seral stages of forest succession. The stubs and the stubs, snags, and live trees in the tree islands may be of more use for nesting to these species as the forests regenerate in the cutblocks.

The robust study design in the Donna Creek has effectively determined the mitigative effects of stubs and tree islands on cavity-nesting birds very early in the successional cycle. However, cavity-nest searches need to be repeated at frequent intervals in the future to properly determine the medium and long-term effects of this mitigation for cavity-nesting birds, particularly early in the successional cycle as potential nest predators such as red squirrels begin to reoccupy the experimental cutblocks. Annual cavity-nest censuses inside the experimental blocks was highly recommended as the most efficient use of monies identified for this project.

TABLE OF CONTENTS

List of Figures v

List of Tables vi

List of Appendices vii

Acknowledgements vii

1.0 INTRODUCTION 1

1.1 Objectives 2

2.0 STUDY AREA 3

3.0 METHODS 3

3.1 Study Design 3

3.1.1 Experimental blocks 3

3.1.2 Controls 5

3.2 Cavity Nest Searches 7

3.2.1 Ad Hoc Searches 1995 7

3.2.2 Systematic Surveys 1996 8

3.3 Cavity Nest Monitoring 9

3.4 Cavity Nest Data Collection 10

3.3.1 Nest-tree Surroundings 11

3.3.2 Nest-trees 12

3.3.3 Nest Cavities 13

3.4 Data Analysis and Management 13

3.4.1 Nesting Response of Cavity Nesters to Treatments 14

3.4.2 Nest-tree Surroundings 14

3.4.3 Nest-tree Characteristics 15

3.4.4 Nest Cavities 15

3.4.5 Effects of Blowdown in Tree Islands on Birds 15

3.4.6 Data Management 16

4.0 RESULTS 17

4.1 Cavity Nest Searches 17

4.2 Cavity Nest Monitoring 22

4.3 Nesting Response of Cavity Nesters to Treatments 22

105-02377/

4.0 RESULTS (continued)

4.4 Nest-tree Surroundings 24

4.4.1 Nest Distances to Tree Islands and Old-Growth Forest 24

4.4.1 Stub Densities, and Physical and Vegetation Characteristics .. 26

4.4.3 Interspecific and Intraspecific Nest Spacing 28

4.5 Nest-tree Characteristics 31

4.5.1 Type, Species and DBH of Nest-trees 31

4.5.2 Decay Characteristics of Nest-trees 33

4.6 Nest Cavities 34

4.7 Other Possible Cavity Nesting Birds 35

4.8 Effects of Blowdown in Tree Islands on Birds 36

5.0 DISCUSSION 37

5.1 Potential Numbers of Nest-tree Stubs 37

5.2 Vegetation Differences around Dispersed Stub Nest-trees 39

5.3 Effects of Blowdown in Tree Islands on Birds 39

5.4 Mitigative Values of Stubs and Tree Islands 40

5.4.1 *Picoides* Woodpeckers 40

5.4.2 Secondary Cavity Nesting Birds 43

5.4.3 Northern Flickers 44

5.4.4 Other Species 45

5.5 Stub Densities and Tree-island Sizes 46

5.6 Longer term Effects 46

6.0 CONCLUSIONS and RECOMMENDATIONS 47

6.1 Mitigating the Effects of Clearcutting 47

6.2 Future Studies at Donna Creek 48

7.0 LITERATURE CITED 49

List of Figures

Figure 1. Location of the Donna Creek study area in the Williston Reservoir watershed, north-central British Columbia, Donna Creek Forestry/Biodiversity Project. 4

Figure 2. Locations and arrangement of experimental cutblocks (Blocks 5516, 5546 and 5547), Clearcut Control cutblocks (Blocks 5510, 5549 and 5550) and the Old-Growth Control areas (OG1, OG2 and OG3) within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project, 1996. 6

Figure 3. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5516 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. 18

Figure 4. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5546 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. 19

Figure 5. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5547 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. 20

Figure 6. Cavity nest locations and bird species using nests in 1995 in Experimental Blocks 5516, 5546 and 5547, Donna Creek Forestry/Biodiversity Project.....29

Figure 7. Cavity nest locations and bird species using nests in 1996 in Experimental Blocks 5516, 5546 and 5547, Donna Creek Forestry/Biodiversity Project.....30

Figure 8. Percentage of stubs ≥15-cm diameter at breast height (DBH) considered suitable for primary cavity excavation by species and DBH class in the 20% decay-assessed stub sample, Donna Creek Forestry/Biodiversity Project, 1996.....38

List of Tables

Table 1. Number of nests and nest-trees used by cavity-nesting bird species within the experimental cutblocks, control areas (Old-Growth Control [**OG**] areas and Clearcut Control [**CC**] cutblocks), and continuous old-growth forest adjacent to the study cutblocks, Donna Creek Forestry/Biodiversity Project, 1995-1996. 17

Table 2. Nest-tree type used by cavity-nesting birds in 1995 and 1996 within experimental cutblocks (Blocks 5516, 5546 and 5547), Donna Creek Forestry/Biodiversity Project. 21

Table 3. Numbers of active cavity nests in 1995 and 1996 in each experimental treatment unit, and ANOVA test statistics for treatment factor, year and block interactions, Donna Creek Forestry/Biodiversity Project, 1995-1996. 23

Table 4. Mean distances to a forested habitat (continuous forest or tree islands) for cavity nests used in dispersed stubs during 1995 and 1996, and randomly selected stubs, in experimental cutblocks within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. 25

Table 5. Pair-wise comparison of habitat characteristics (moisture regime, vegetation cover by strata layer, stump, snag, stub and upturned root wad densities, and mean diameter at stump height [DSH]) at 1995 and 1996 dispersed stub nest-trees and the nearest point-count station to each nest-tree stub, Donna Creek Forestry/Biodiversity Project, 1995-1996. 27

Table 6. Number and type of cavity nest-trees in each experimental cutblock including nest-trees with active nests in 1995-1996, as well as stubs with cavities that were excavated prior to 1995, but were not used for nesting in 1995 or 1996, Donna Creek Forestry/Biodiversity Project, 1995-1996 31

Table 7. Mean diameter (cm) at breast height (1.3 m, DBH) of nest-trees, by stem type, tree species and location, with active cavity nests in 1995-1996 , and the DBH descriptive statistics (mean, standard error and range) for all stubs ≥15-cm DBH (from Gyug and Corbould 2002), Donna Creek Forestry/Biodiversity Project. All data collected during nest plot and stub assessments in summer 1996. 32

List of Appendices

Appendix A. Location co-ordinates and characteristics of cavity nest-trees for nest-trees with active cavity nests in 1995 and 1996, Donna Creek Forestry/Biodiversity Project A-1

Appendix B. Location co-ordinates and characteristics of numbered stubs with cavities that were not used for nesting in 1995 or 1996, Donna Creek Forestry/Biodiversity Project B-1

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1.0 INTRODUCTION

The Donna Creek Forestry/Biodiversity Project was initiated in 1990 as a cooperative venture of the Peace/Williston Fish and Wildlife Compensation Program and Fletcher Challenge Canada Ltd (now Slocan Forest Products Ltd.). The aim of the project is to develop and test alternative timber-harvesting techniques designed to benefit tree-cavity-nesting birds and mammals.

In British Columbia, more than 90 species, or about 16% of the native wildlife, can be counted as wildlife tree users (Backhouse 1993). Many of these species rely on holes in trees for their nests or roosts. Bird species that excavate their own nesting or roosting holes include woodpeckers, sapsuckers, chickadees and nuthatches, and are called primary cavity excavators. Other species, including wrens, bluebirds, tree swallows, Vaux's swifts, some of the owls, and some of the smaller raptors depend on the cavities excavated by the primary cavity excavators for roosts and nests, as well as sometimes using naturally existing cavities in trees. Mammals including many species of bats and birds such as brown creepers use areas under large pieces of flaking bark for nests or roosting sites, as well as sometimes using cavities in trees. Mammals such as red squirrels, flying squirrels, marten and fisher also often use cavities in trees for raising their young.

Animals that nest or roost in tree cavities are at risk in the managed forest because conventional clearcutting methods typically remove all standing trees and snags. This will be particularly true for species that use the many standing dead tree stems remaining in the earliest successional stages immediately after wildfire because large-scale commercial timber harvesting has now largely replaced wildfire as the major agent of forest renewal. However, there may also be risks in the mid and older seral stages, if cavity-using species depend at that time on the cavities in tree stems that would have been left standing in the post-wildfire successional series, and which would not be available after conventional clearcutting. Imbeau et al. (2001) compared birds in the boreal forests in North America with the same or similar species in Scandinavia where the first rotation of timber harvesting is largely already complete. They identified particularly high levels of threat to certain boreal forest birds, particularly three-toed woodpeckers, black-backed woodpeckers, boreal owls, boreal chickadees and brown creepers, all of which occur in the Donna Creek study area.

In addition, Worker's Compensation Board regulations prohibited the maintenance of any standing diseased or dead trees taller than 3 m on worksites (Backhouse 1993). This

project was designed to test whether creating 3-m high stumps (stubs) and retaining small residual tree islands during clearcutting would benefit cavity-using animals. Similar research, that was published only after this project was already underway, has shown that stubs can be useful to some cavity-nesting animals in clearcut harvest areas (e.g. Morrison 1992, Bennett 1994, Harris 1996). However, the goal of this project is also to examine the long-term benefits or effects of both stubs and tree islands on cavity-nesting animals, and to look closely at the characteristics and locations of these features that make them useful to animals. Annual and other reports detailing the initiation and other phases of this project are available (Dawson et al. 1992, Murray 1992a, Murray 1992b, Wood 1992, Wood 1994, Wood 1995, Gyug and Summers 1995, Corbould and Hengeveld 1998).

The objective of this report is to document the nesting sites and nest characteristics of cavity-nesting birds within the project sites in 1995 and 1996. Complementary studies at the same sites have included a study of the behavioural and habitat use of cavity-nesting birds in 1995 (Joy and van den Driessche 1998), and point-count surveys for all species of birds in 1995 and 1996 (Gyug 1997). Preliminary results from 1995 cavity nest searches have been presented in Joy and van den Driessche (1995), and from 1996 in van den Driessche and Joy (1998). These results have been more completely analyzed and presented in this report, as well the methods sections from those reports are repeated here so that all information can be found in one report.

1.1 Objectives

The objective of this study was to determine which forest elements(i.e., trees, stubs, snags, and tree islands), left behind after the alternative timber-harvesting treatments, were used for nesting by breeding cavity-dependent birds. The specific objectives were to:

1. Find all nest sites of cavity-nesting birds in 1995 and 1996 in the Donna Creek alternative harvesting study sites,
2. Describe the physical and structural characteristics of each nest site and its surroundings,
3. Assess the fledging success of each nest site that was active in 1996,
4. Compare characteristics of the stub nest sites to the characteristics of unused, but potential, stub nest sites,
5. Assess the success of the alternative timber-harvesting treatments at providing the structural attributes that cavity-nesting birds need to nest successfully.

2.0 STUDY AREA

The Donna Creek study area is located at the south end of the Wolverine Range of the Omineca Mountains, approximately 80 kilometres northwest of Mackenzie and 240 km north of Prince George, British Columbia (Figure 1). Detailed location notes and geographical descriptions of the study area are available in Dawson et al. (1992). The study area is in the Manson Plateau Ecosection of the Omineca Mountains Ecoregion of the Sub-Boreal Interior Ecoprovince.

The study plots are in the moist-very cold subzone of the Engelmann Spruce–Subalpine Fir Biogeoclimatic Zone (ESSFmv3; MacKinnon et al. 1990). This ESSF subzone is characterized by an ericaceous shrub layer, a sparse cover of herbs, and a relatively dense moss layer. Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are the dominant climax tree species, with lodgepole pine (*Pinus contorta*) as a widespread seral species (Dawson et al. 1992). Throughout this report, these tree species are referred to as spruce, balsam and pine respectively. Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) was the only other mature tree species that occurred in the study plots; this subspecies is referred to as cottonwood throughout this report. Trembling aspen (*Populus tremuloides*) also occurs in the area.. Detailed structural and biophysical attributes for the study area are available in Gyug and Corbould (2002) as are maps of each block showing block boundaries, treatment unit boundaries, roads, tree islands and point-count stations.

3.0 METHODS

3.1 STUDY DESIGN

3.1.1 EXPERIMENTAL BLOCKS

The study design was a randomized block two-factor ANOVA with two levels of each between-subjects factor (i.e., a 2x2 ANOVA). The first factor was the retention of stubs (high stumps cut at 3-m height by a feller-buncher) within the clearcut. Prescribed levels chosen were 1)absence and 2)densities of 8-10/ha. Final densities of stubs in the gross harvested areas, i.e., including landings and roads, were 0 - 0.3/ha in the "absent" areas, and 4.7-9.5 per ha in the stubbed areas (Gyug and Corbould 2002). The second factor was the retention of mature tree islands, or patches of residual forest, within the clearcut.

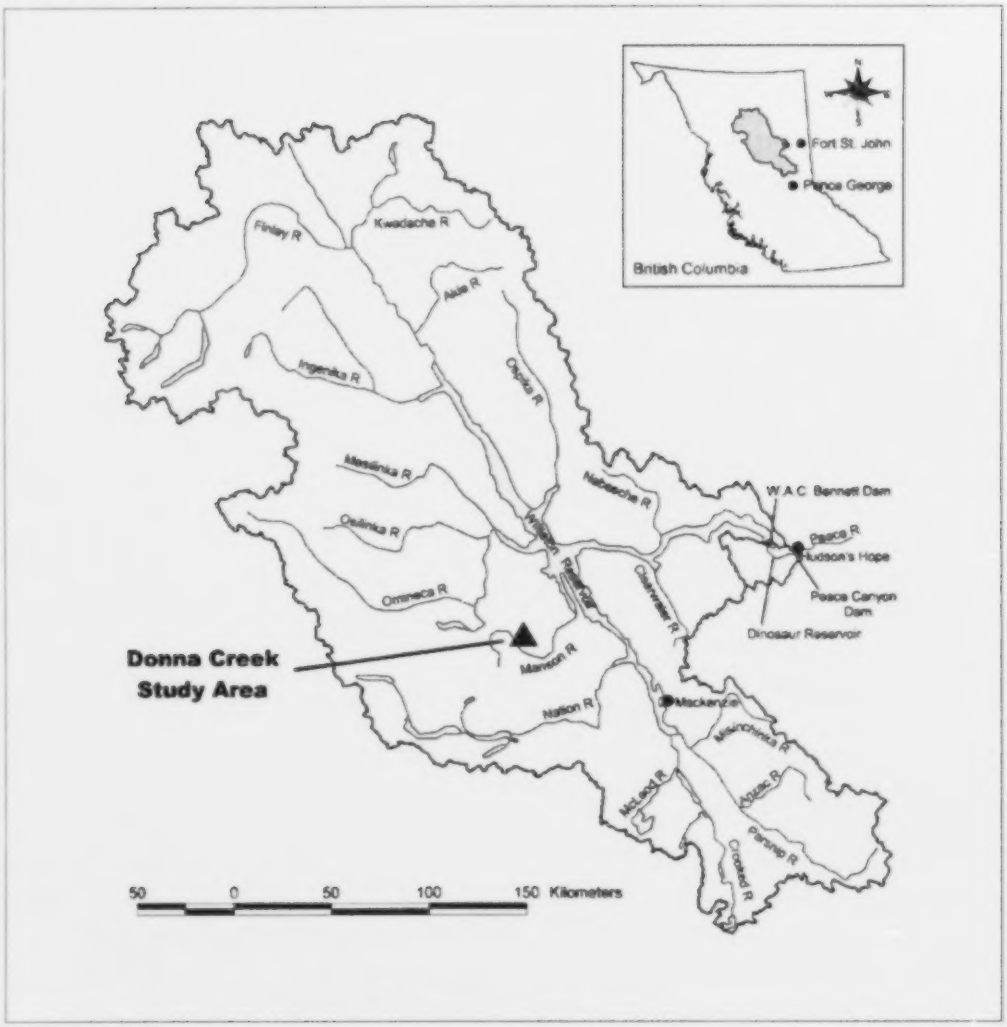

Figure 1. Location of the Donna Creek study area in the Williston Reservoir watershed, north-central British Columbia, Donna Creek Forestry/Biodiversity Project.

Prescribed levels chosen were 1)absence and 2) one tree island of about 0.25 ha for every 8 ha of clearcut. Final tree-island sizes ranged between 0.18 and 0.41 ha (mean of 0.26 ha) with one extra island of 1.4 ha created because of slope stability concerns (Gyug and Corbould 2002).

A complete statistical explanation of the study design can be found in Gyug (1997). There are four possible combinations of the two experimental factors at each of two given levels. These combinations make the following four treatments:

- **Clearcut (CT):** No stubs and no tree islands,
- **Stub (SB):** Stubs but no tree islands. The stubs were dispersed fairly evenly over the harvested area, and are termed dispersed stubs.
- **Tree island (TI):** Tree islands but no dispersed stubs. A fringe of stubs was created at the perimeter of each tree island during timber harvest, and these are termed perimeter-stubs in this report. Therefore, for the most part, each tree island is also a high-density patch of stubs as well as a patch of residual forest.
- **Stub-and-Island (SI):** Dispersed stubs throughout the harvested area as well as tree islands with a fringe of perimeter-stubs.

The three experimental cutblocks (Blocks 5516, 5546 and 5547; see Figure 2) in the project area made for a randomized block study design with 3 replicates of each treatment. Each of the three experimental blocks was divided into four sections of about 25 ha each, and one of each treatment applied randomly in each experimental block. Each of the treatments is referred to hereafter by their two-letter code **(CT**, **SB**, **TI**, or **SI)** to avoid confusion between the stub and tree-island factors, and the stub and tree-island treatments, which are each a combination of different levels of the two factors. Where analyses refer separately to the tree-island or harvested portions of the **TI** or **SI** units, then their respective codes **TIi** or **SIi,** and **TIh** or **SIh** are used.

3.1.2 CONTROLS

To discount the possibility that "neighbour effects" of adjacent areas with stubs or tree islands were contributing to some bird use of the Clearcut Treatments (CT), large clearcuts

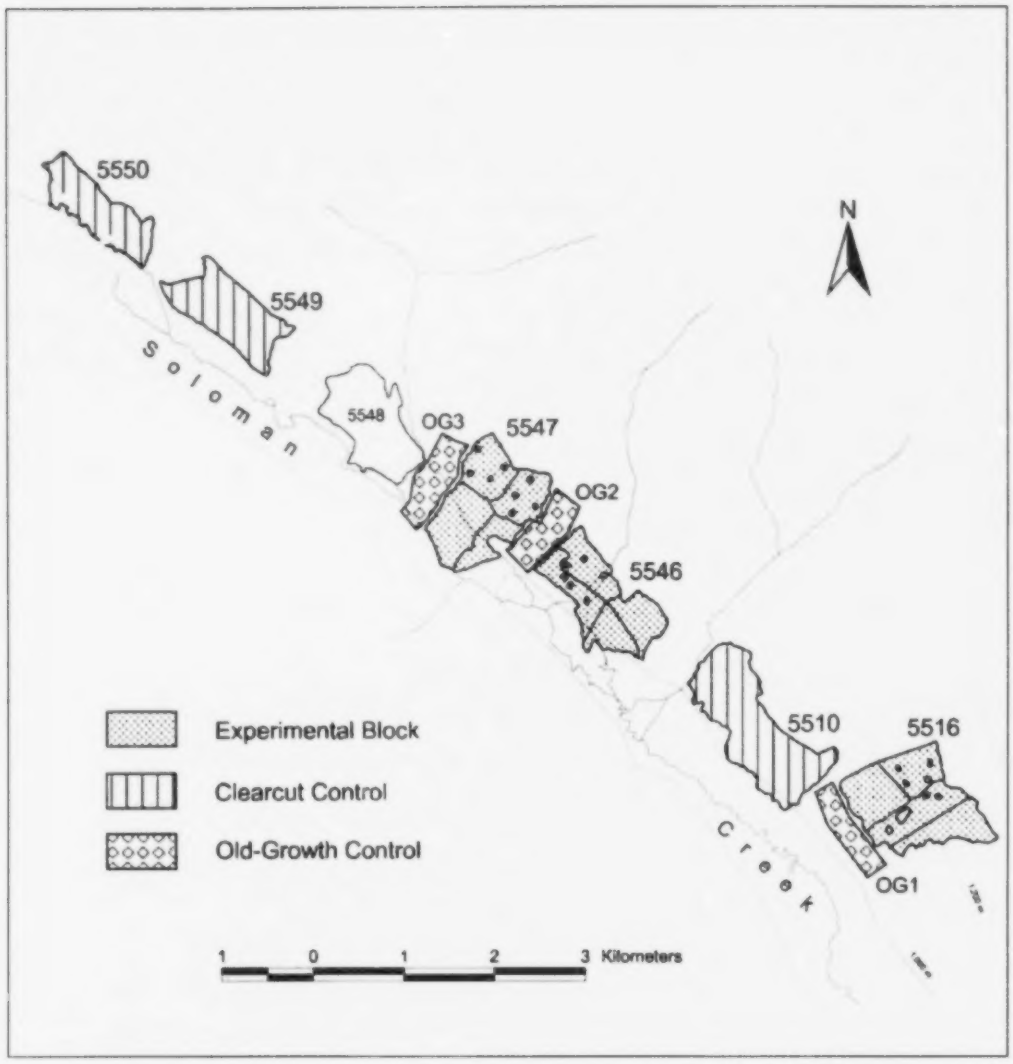

Figure 2. Locations and arrangement of experimental cutblocks (Blocks 5516, 5546 and 5547), Clearcut Control cutblocks (Blocks 5510, 5549 and 5550) and the Old-Growth Control areas (OG1, OG2 and OG3) within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project, 1996.

with no stubs or tree islands were selected within the Donna Creek drainage to act as controls to the treatment clearcuts. These cutblocks (5510, 5549 and 5550, see Figure 2) were termed **Clearcut Controls (CC)**.

Breeding bird point-count sampling was conducted in old-growth forest adjacent to each of the experimental cutblocks (5516, 5546 and 5547). These areas were termed **Old-Growth Controls (OG).** This permitted comparisons of mean breeding bird use in each of the four treatments with the mean use in the old-growth forest. Cavity-nest searches in old-growth forest were not limited to the same areas where breeding bird point-count sampling was undertaken, but were extended to all old-growth forests immediately adjacent to the experimental cutblocks. These forests are termed continuous forests, to distinguish them from the **OG** Control areas, and from the forested tree islands.

3.2 Cavity Nest Searches

Procedures used to search for cavity nests within the study sites were different in 1995 and 1996. Below are the search techniques employed for the two survey periods as presented in Joy and van den Driessche (1995) and van den Driessche and Joy (1998).

3.2.1 Ad Hoc Nest Searches 1995

In 1995, cavity nest searches did not follow the same rigorous protocols as 1996 (see methods below). Breeding bird point-count surveys were repeated seven times in each treatment and control between 22 May and 26 June. Behavioural surveys were conducted on at least 19 days within the same period with sampling time equally apportioned between experimental blocks and treatment units within blocks. Some nests were noticed during both these surveys. In other places where cavity-nesters had been seen repeatedly during either the point-count or behavioural surveys, intensive local searches were undertaken. Nests were located during intensive searches by following adult birds until they were seen entering a nest cavity or by listening for the vocalizations of young inside nest cavities. Nest searches only began after breeding bird point-count surveys were terminated for the day at 10:00 hours, or when point-count surveys were not able to be conducted, and continued for a variable length of time.

Further to the intensive local nest searches in locations where cavity-nesting birds were observed, each treatment cutblock, including the tree islands, was searched by three surveyors on a number of occasions throughout the breeding season (29 May - 26 June). These additional searches were used to locate other possible cavity-nesting birds and

cavity nests that might not have been noticed during the other surveys. Sampling methods were therefore on an ad hoc basis but, nonetheless, the surveyors were confident that all cavity nests in the treatment areas (**CT**, **SB**, **TI** and **SI**) were found. No specific nest searches were conducted in or adjacent to **CC** units but some cavity nests were found during breeding bird point-count sampling, including when traveling between the sites.

3.2.2 Systematic Nest Surveys 1996

In 1996, two surveyors located nests using 5 different methods: systematic searches, call playbacks, intensive local searches, stub assessments and incidentally during point-count surveys. The details of each search protocol have been described in van den Driessche and Joy (1998), and are repeated below with only minor changes from that document.

Call Playback Searches From 29 May to 11 June 1996 (before woodpecker eggs began to hatch), one observer carried a portable tape machine and played pre-recorded woodpecker calls at approximate 100-m intervals throughout the three treatments (**SB**, **TI** and **SI**) and block perimeters. The other observer followed the systematic search protocol (see below), walking 50 m away. Additional woodpecker calls were played in the immediate vicinity of timbered islands and each timbered island was searched intensively for signs of cavity-nesting birds. Tapes contained territorial calls and drumming of hairy woodpeckers, three-toed woodpeckers, black-backed woodpeckers, and northern flickers. Pre-recorded calls of each species lasted approximately 20 sec. Calls were played in random species order and not every species was played at each stop. If a response was obtained, the woodpecker was followed until it was either lost or a nest was found. Call playback searches differed only from systematic searches in that a tape was played to elicit a response from resident woodpeckers. Call playback searches occurred between 10:00 and 15:00 hours with even sample effort in each of the **SB**, **TI** and **SI** treatments and additional effort in the block perimeters. It took approximately 1 hr to search each treatment unit and an additional 2 hrs to walk the block perimeter. Each treatment block was visited at least three times for call playback searches.

Systematic Searches From 12 June to 24 June 1996, searches for signs of cavity nests (cavities in trees, stubs, or snags; wood chips at the base of trees; observing adult birds; listening for the begging calls of juvenile birds) were carried out. Walking approximately 50 m apart, two observers systematically searched throughout the **SB**, **TI** and **SI** treatments with each observer searching approximately half of each treatment. For searches of timbered islands, observers were spaced much closer than the 50 metres used

outside the timbered islands, and searches were more intensive. An entire treatment was completed before the next treatment was started. The perimeter of the blocks (the surrounding old-growth edge) were treated as one search area. The perimeter was searched by walking 10 metres on either side of the cutblock boundary. Protocol of perimeter searches varied. Typically observers split up, each walking half of block perimeter, but on occasion the two observers walked the block perimeter together. Nest searches followed morning counts, taking place from 10:00 to 15:00 hours. Each treatment block was visited 4 times with even sample effort spent in each of the **SB**, **TI**, and **SI** treatment types (approximately 1 hr per treatment type and an additional 2 hrs along the block perimeter).

Intensive Local Searches From 25 June to 29 June 1996, when young were vocal and nests were more easily located, nest searches were conducted from dawn until 10:00 hours. Searches concentrated on areas where a high number of cavity-nesting birds had been recorded during point counts in **OG**, **SB**, **TI** and **SI** treatments and block perimeters, and did not follow any systematic sample protocol. Intensive local searches consisted of following adult birds until they were either lost or a nest was located, and/or listening for the vocalizations of young inside nest cavities. One search could take anywhere up to 3 hrs, and was not always successful. These intensive local searches were also conducted on days when rain or wind interrupted breeding bird surveys.

Stub Assessments In June and July, as part of the stub decay assessment portion of the Donna Creek Forestry/Biodiversity Project, each 3-m stub in Blocks 5516, 5546 and 5547 (except for those stubs located at the perimeter of tree islands in the **TI** treatment) was visited by Peace/Williston Fish and Wildlife Compensation Program staff or contractors. The presence of cavities was recorded and the information was provided to the cavity-nest surveyors for further examination and monitoring.

Incidental Sightings While conducting breeding bird point-count surveys between 29 May and 4 July, cavity-nesting birds were sometimes noted flying to cavities. Nest locations were noted for future monitoring.

3.3 Cavity Nest Monitoring

All potential nest cavities were investigated during nest searches. If a nest cavity was found, but identified as inactive, it was checked again later on an ad hoc basis to confirm its status. In 1995, all active cavity nests were monitored on an ad hoc basis until the young were no longer noted in the nest. Fledging date was noted whenever possible, as

well as whether young had been lost to predators. Numbers of eggs and young were not monitored in 1995.

In 1996, each active nest in the experimental cutblocks was initially accessed using a ladder or climbing equipment, and viewed using a dental mirror and small flashlight to determine egg and/or nestling numbers. Further monitoring was at approximate 4-day intervals, but as often as once per day during the period when most young fledged (26 June - 8 July). Nests were monitored by listening for the calls of the young inside the cavity and, where possible, monitored during the point-count survey period while traversing between survey stations. If nests were not on the survey route or if nests were silent, nest status was evaluated after point-counts surveys were completed. Nest monitoring continued until the young had fledged, or until young were no longer found in the nest. Once nests were empty, cavities were inspected for signs of predation.

3.4 Cavity Nest Data Collection

In 1996, the characteristics of each cavity nest that had been active in 1995 or 1996 were measured. These included descriptions of nests at three levels: nest-tree surroundings, nest-tree structure, and nest cavity. Cavity-nesting birds in the study sites in 1995 and 1996 only nested in stubs, snags and live trees (i.e., in standing stems). For simplicity, the structure holding each nest is termed the "nest-tree", even though they were sometimes stubs or snags, and thus not live trees. Nest cavity data was collected between 25 June and 8 July 1996, but only after the young had left each nest.

The species of bird using each nest was recorded along with the metal tag number for any nests in numbered stubs. Precise locations of nest-trees are only known for those that were in numbered stubs for which GPS locations were recorded in 1996 (see Gyug and Corbould 2002). Only approximate locations are available for the rest of the nest-trees based on sketch maps. Distance from the cutblock perimeter, or from a timbered tree island, was recorded for each nest-tree. The experimental treatment unit of each nest was recorded, and whether the nest was on the perimeter of the old-growth forest if it was adjacent to the experimental cutblocks, or the number of the tree island in which the nest was located. For data tracking, each nest-tree was assigned a number based on the block that it was located in (or adjacent to) and then uniquely numbered. For example, nest-tree **47NP06** is nest-tree #6 within or near Block 5547, with NP standing for "Nest Plot". Nest-trees for which no nest plot was completed were assigned letters, rather than numbers, in the dataset later, e.g., nest-tree **46NP?A**.

3.3.1 NEST-TREE SURROUNDINGS

To characterize the area surrounding the nest, vegetation and biophysical descriptions were collected within 11.3-m and 50-m radius plots centred on the nest-tree. This was the same set of data recorded at each of the breeding bird point-count survey stations (see Gyug and Corbould 2002). The number of stumps, snags and root wads, as well as an estimate of CWD, were therefore part of the suite of characteristics measured near each nest and at each breeding bird point-count station; these attributes were described because some cavity-nesting birds can sometimes nest in low-cut stumps, logs and root wads, and woodpeckers were noted feeding on low-cut stumps in the cutblocks. These features might provide some estimate of other potential perching, feeding and/or nesting sites in the vicinity of used nests.

Within the 50-m plot, slope, aspect, elevation, macroslope position, moisture regime (type and percent coverage), and the number of stubs were recorded. In **SB** and **SI** treatment areas, the metal tag number of stubs within the 50-m plot were also recorded, as well as within a 25-m radius plot as a subset of the 50-m radius plot.

The number, diameter at breast height (DBH), height class, and Wildlife Tree Class (WTC, based on external visual assessment) of all snags was recorded within a 25-m radius of each nest-tree. Snags in this case only included standing dead trees that had not been numbered during the other phases of this project, and therefore did not include stubs. This methodology differed slightly from the information collected at the breeding bird point-count stations where snag information was only recorded inside an 11.3-m radius plot.

Within the 11.3-m plot, the percentage of ground cover by different soil moisture regimes from xeric to hydric, and the percentage cover by surface substrates classed as Wood, Bedrock, Cobble, Mineral, Organic[1], or Water were estimated (Habitat Monitoring Committee 1990). Percent cover of vegetative species was recorded in 6 strata following protocols in Procedures for Environmental Monitoring (Habitat Monitoring Committee 1990). The percent cover of mosses and lichens, herbs, low shrub (<2 m in height), tall shrub (2-10 m), sub-dominant trees (>10m but not reaching main canopy) and canopy trees (>10 m and forming main canopy) were recorded. Also recorded were the number of low-cut stumps (i.e., standard height of trees cut by a feller-buncher) by Diameter at

11

[1] Field surveyors collected Organic layer percentage that included both living and dead matter, rather than just soil litter and dead material.

Stump Height (DSH) class; and the number of upturned root wads, classed by 1-m height intervals.

Sampling methods for CWD partially followed the draft guidelines developed by the Vegetation Resources Inventory (BC Ministry of Forests 1996). Amount (number of pieces), length of each piece, diameter of piece at largest end, and Decay Class of CWD were measured along 2 right-angle 24-metre transects that were centred on the nest-tree or point-count plot centre, with the first transect chosen in a random direction and the second bearing being an additional 90°.

3.3.2 NEST-TREES

Cavity-nesting birds observed in the study sites in 1995 and 1996 only nested in stubs, snags and live trees, which are collectively termed nest-trees. For most nest-trees that were active in 1995 or 1996, the following information was collected in 1996:

- species,
- DBH,
- nest-tree height,
- decay stage (= Wildlife Tree Class),
- percentage of bark remaining (<50%, 50-75%, >75%),
- root condition (1, 2, 3, or D) as follows:
  1 - lateral roots free from decay up to 1 m from stem
  2 - >75% lateral roots free from decay up to 1 m from stem
  3 - >50% lateral roots free from decay up to 1 m from stem
  D - <50% lateral roots free from decay up to 1 m from stem,
- dominant heartwood condition (1,2,3 or D) as follows:
  1 - hard core (can be shaved with a pen knife)
  2 - spongy core (remains intact, somewhat flexible, can be shaved)
  3 - soft core (breaks apart, flaky)
  D - very soft core (crumbles, powdery, unsound)
- dominant sapwood condition (1,2 or 3) as for heartwood above,
- any obvious tree defects,
- height, opening size and direction of any cavities found,
- tree age from annual rings, and if possible for dead trees as well,
- any obvious stem defects or signs of decay such as conks, heartrot, broken tops, frost cracks, broken branch holes, or scars,
- the tag number if the nest-tree stem was tagged (although many of the stems tagged in 1996 had not yet been tagged by the time nest-tree plots were done, so tag number was not always available).

3.3.3 Nest Cavities

At each cavity that was active in 1995 or 1996, the characteristics of the cavity were recorded after the young had fledged in 1996. The species of bird using the cavity in that year was recorded. A cavity number was assigned to each cavity for nest-trees that contained more than one cavity that was used. Cavity nests were accessed using a ladder or climbing equipment, unless they were considered too unsafe to climb, in order to take the following measurements:

- entrance dimensions (length and width) to the nearest cm,
- cavity depth using a fishing weight on a line lowered into the cavity,
- cavity orientation using a compass with the base placed against the cavity entrance,
- cavity height using a tape held at the base of the cavity entrance and dropped to the ground,
- whether the cavity was in the top, middle or bottom third of the nest-tree,
- the estimated age of the cavity, i.e., newly excavated, 1 year old, etc., if possible, and
- the type of cavity, i.e., excavated by a bird, or existing from other natural causes which were noted separately.

3.4 Data Analysis and Management

Generalized Linear Model (GLM)-ANOVA was used in all ANOVA analyses using NCSS software (Hintze 1992). ANOVA is relatively robust to heterogeneity of variances when the numbers of replicates are equal (Maxwell and Delaney 1990:703), so heterogeneity of variances was not tested. With only three replicates per treatment, it was not possible to test for normality of data distribution, although we have proceeded with ANOVA that assumes normal distributions. ANOVA is also robust to all but extreme violations of the normality assumption if sample sizes are equal (Maxwell and Delaney 1990:708). All tests made were two-tailed. The probability of a Type I error (α) was set at 0.05 throughout the analyses. Student's t-test assuming unequal variances was used to test differences in DBH means using the procedure in the Microsoft Excel 97 Data Analysis Toolbox. Students t-test was used to make pair-wise comparisons using the procedure in the Microsoft Excel 97 Data Analysis Toolbox. Linear correlations were run using the procedure in the Microsoft Excel 97 Data Analysis Toolbox.

3.4.1 Nesting Response of Cavity Nesters to Treatments

The 2x2 ANOVA model outlined in section 3.1.1 was used to determine stub and tree-island effects on the abundance of cavity nests in the experimental cutblocks. The year and block factors were added to the model to test for differences in cavity nest numbers that might be attributable to year or some other unique block effects.

Comparisons were not made to the Old-Growth Control (**OG**) areas because the total number of cavity nests in the **OG** areas was unknown since they were not censused to find every cavity nest. The Clearcut Controls (**CC**) had been established to determine if there were any neighbour effects on breeding birds because the Clearcut Treatments (**CT**) were immediately beside the stub and tree-island areas. However, no statistical comparisons of numbers of cavity nests were made between **CC** and **CT** units because there were no nests in the **CT** units, and only one nest in each of 1995 and 1996 in one of the **CC** blocks.

3.4.2 Nest-tree Surroundings

Cavity nest surroundings were examined for each bird species by the broad habitat type that they occurred in, i.e., Stubbed Area, Tree Island or Continuous Forest, since these habitats were very different by experimental design. Further analyses of nest-tree microsites were only completed within each broad habitat type, and where sample sizes permitted for each bird species.

All cavity nests within the experimental treatments but outside of tree islands, were in stubs. Parameters examined for these nest-tree stubs included local stub density and distance from forest or tree island. These were compared to the same parameters as derived from GIS coverages for a set of randomly-selected stubs. To compare other parameters that were not available in the GIS layer, but only available from breeding bird point-count stations, pair-wise comparisons of differences of means were made using the nearest point-count station to each nest-tree to complete the pair.

Within the tree-island habitat, tree-island size and distance to continuous forest was examined to see if there was any effect on nest use by each species using linear regression. Vegetation and other parameters were not examined for these nests within tree islands since nests were often at the perimeter of tree islands and all breeding bird point-count stations had been placed at the center of tree islands. Consequently, the vegetation, stub, tree and snag densities would be different between these nests and the point-count station results by design.

Vegetation and other parameters at nest-trees within the continuous old-growth forest were not statistically compared to point-count station results because the nest-trees were almost all at the forested edges of the experimental cutblocks, and not in the same relative locations as the breeding bird point-count stations in the **OG** areas. The only examination for these nests consisted of comparisons of bird species use of these perimeter areas with the other broad habitat types.

3.4.3 Nest-tree Characteristics

The type of nest-tree (stub, snag or live tree) used by each bird species was examined in the experimental units. The tree species used were examined, and within tree species, comparisons made of mean stub nest-tree DBH to mean DBH of all stubs. Sapwood and heartwood decay characteristics were summarized for nest-trees used in 1995-1996 by bird species groupings (primary cavity excavators, weak excavators, and secondary cavity-nesting species). Stubs that contained bird-excavated cavities that were made prior to 1995 were not analyzed for decay characteristics because the year of use was unknown.

3.4.4 Nest Cavities

The only cavity characteristic for cavity nests that were active in 1995 or 1996 presented in this report is height, and position of cavities in the top, middle or bottom third of stubs. Although depths of cavities were supposedly collected in the field, no measurements were entered into the database, and so were not analyzed here. Cavity orientation was not consistently recorded, and so is also not presented here. Estimated age and origin of cavities were used to determine whether woodpeckers had recently excavated the cavity nests that they used in 1995 or 1996.

3.4.5 Effects of Blowdown in Tree Islands on Birds

Blowdown rates (or using the inverse, and rephrased as survival or retention rates) were estimated in 4 tree islands in Block 5547 between 1992 and 1996 (Gyug and Corbould 2002). Two of the tree islands (Isl 47-1 and 47-4) had relatively low retention rates of snags and trees (estimated at 30%), and two (Isl 47-6 and 47-8) had relatively higher retention rates of snags and trees (estimated at 71%); stubs at the perimeter of Isl 47-6 and 8 had high retention rates (99%). The raw breeding bird point-count data collected in 1995 and 1996 (see Gyug 1997) was examined to see if there were any obvious differences in bird community composition between the two sets of tree islands. The numbers of cavity nests, and numbers of observations of cavity nesting birds in 1995 and 1996 from

point-count stations were also examined to see if there were any obvious differences in cavity nester use of the two sets of tree islands. This examination only included cavity-nesting birds that were recorded within the tree islands in 1996, i.e., did not include those birds that were recorded within 50 m of the station but were outside the tree island. The "inside the island" field was not recorded in 1995, so in 1995, only observations that were not "Overhead" were considered to be within the tree islands.

3 4.6 Data Management

The data collected in the field was entered into the following files which were used for these cavity nest analyses and this report:

Cavity_nests(95_&_96)_final.xls - Characteristics of cavity stems and nest production.

Cav_etal_final.xls - Physical attributes, CWD and snags surrounding each nest-tree.

Cav_veg.xls - Vegetation composition and percent cover at each nest-tree.

While the raw data resides in the files named above, files were developed for analyses that manipulated the data into formats suitable for analysis. To avoid having to re-manipulate the same raw data for future analyses, these files have been submitted to the PWFWCP along with this final report under the following names:

Cavity_nests_9596_analysis.xls - Contains raw data but then separates that data with manipulations in format to assist analyses in other sheets in the file.

Cavity_nests_pre1995.xls - Data on cavities in stubs that were not occupied in 1995 or 1996, based on examinations of all stubs during tagging and the 20% stub decay-assessment sampling.

Cav_veg2.xls - Contains all data from ***Cav_veg.xls*** above, but in manipulated format to make analyses possible.

5547_Birds_Islands.xls - Data for analysis of bird use of islands in Block 5547 derived from raw point-count data of 1995 and 1996.

Stub_nest_pairs_veg.xls - Analysis files for nest-tree stubs compared to nearest point-count stations.

A list of all the cavity nests used in 1995 and/or 1996 is included in Appendix A. A list of the stubs containing cavities that were not used in 1995 or 1996 is included in Appendix B. This includes the GPS-traversed UTM locations of any nest-trees for which this was available, and the approximate UTM locations for any locations which were derived from sketch maps. The names of the original datafiles from breeding bird point-count stations that were used for comparisons to the nest-tree data can be found in Gyug and Corbould (2002).

Table 1. Number of nests and nest-trees used by cavity-nesting bird species within the experimental cutblocks, control areas (Old-Growth Control [**OG**] areas and Clearcut Control [**CC**] cutblocks), and continuous old-growth forest adjacent to the study cutblocks, Donna Creek Forestry/Biodiversity Project, 1995-1996. Nest-trees include stubs, snags and live trees.

	Experimental cutblocks				Control areas				Continuous forest		
	Outside Tree Islands		Inside Tree Islands[1]		OG		CC				
	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Nests	Nest-trees	Total Nests
Species											
Black-backed Woodpecker	4	2	4	3	0	0	0	0	0	0	**8**
Three-toed Woodpecker	1	1	4	3	0	0	0	0	11	11	**16**
Hairy Woodpecker	0	0	1	1	0	0	0	0	0	0	**1**
Northern Flicker	0	0	1	1	0	0	0	0	0	0	**1**
Mountain Bluebird	6	4	3	3	0	0	2	2	0	0	**11**
Tree Swallow	4	2	2	2	0	0	1	1	0	0	**7**
Red-breasted Nuthatch	0	0	1	1	1	1	0	0	1	1	**3**
All Species	**15**	**9**	**16**	**14**	**1**	**1**	**3**	**3**	**12**	**12**	**47**
Total Number Nest-trees		**8**		**11**		**1**		**2**		**12**	

[1]Inside Tree Islands includes the stubs at the perimeter of the tree island.

4.0 RESULTS

4.1 Cavity Nest Searches

In 1995 and 1996, 47 cavity nests of 7 species were found (Table 1, Figures 3-5). Thirty-one cavity nests of 7 species were found in the experimental cutblocks, and 16 cavity nests of 4 species were found in other areas including the **CC** and, **OG** control areas, and the continuous forest at the perimeter of cutblocks (Table 1). Only 4 cavity nesting bird species were found commonly in the experimental blocks, with between 5 and 9 nests found for black-backed woodpecker, three-toed woodpecker, mountain bluebird, and tree swallow.

The 47 nests were only in 34 actual nest-trees since some nest-trees and cavities were used in both years, and on some occasions by two species in one nest-tree in one year (Table 1). There were 19 nest-trees in the experimental units and 15 in other areas (Table 1). Within

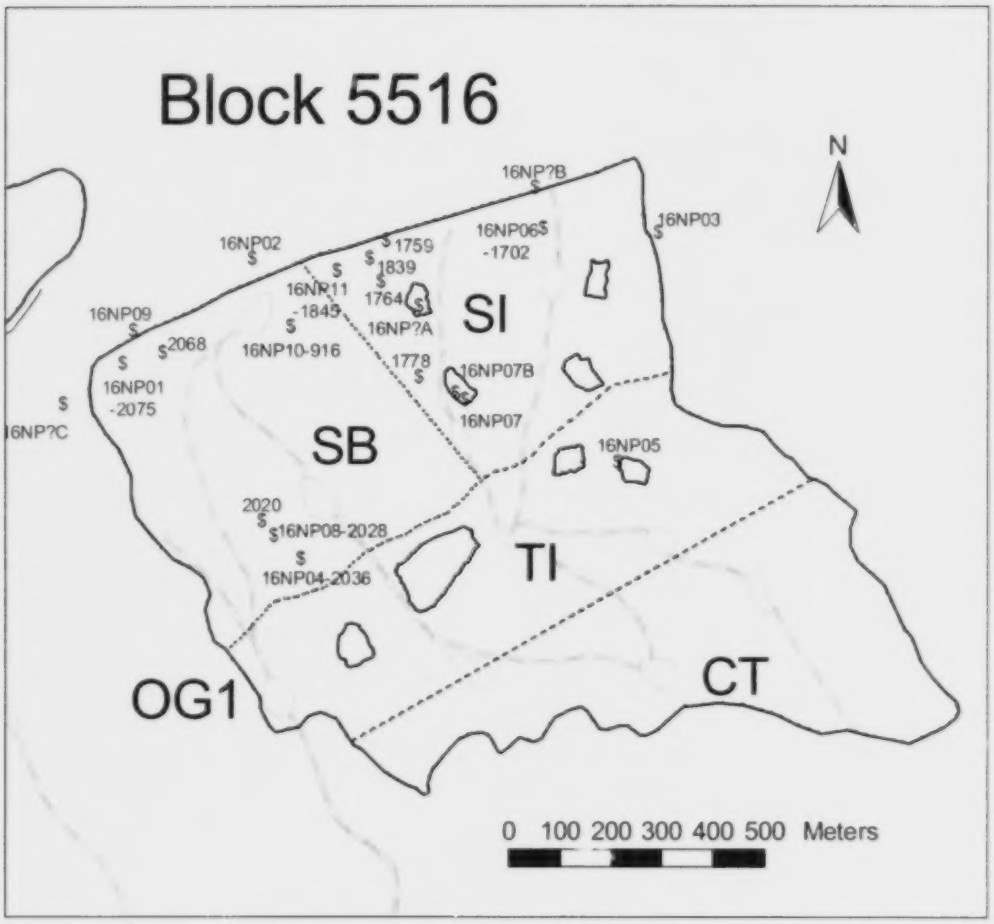

Figure 3. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5516 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. Numbers alone indicate stubs with cavities present prior to 1995; NP numbers alone indicate nest-trees (live trees or snags) with locations in islands or continuous forest outside cutblocks approximate; and NP numbers with stub numbers indicate nest-trees (numbered stubs) that had active cavity nests in 1995 and/or 1996.

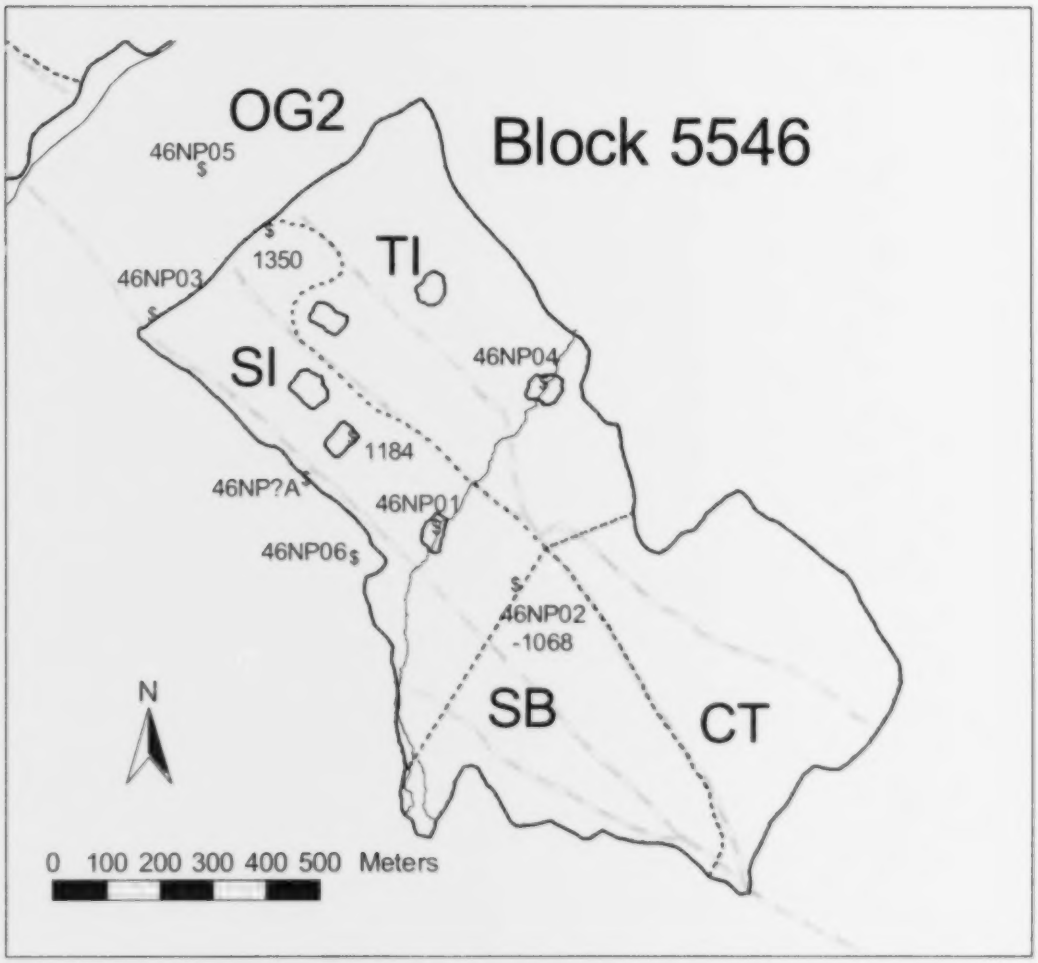

Figure 4. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5546 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. Numbers alone indicate stubs with cavities present prior to 1995; NP numbers alone indicate nest-trees (live trees or snags) with locations in islands or continuous forest outside cutblocks approximate; and NP numbers with stub numbers indicate nest-trees (numbered stubs) that had active cavity nests in 1995 and/or 1996.

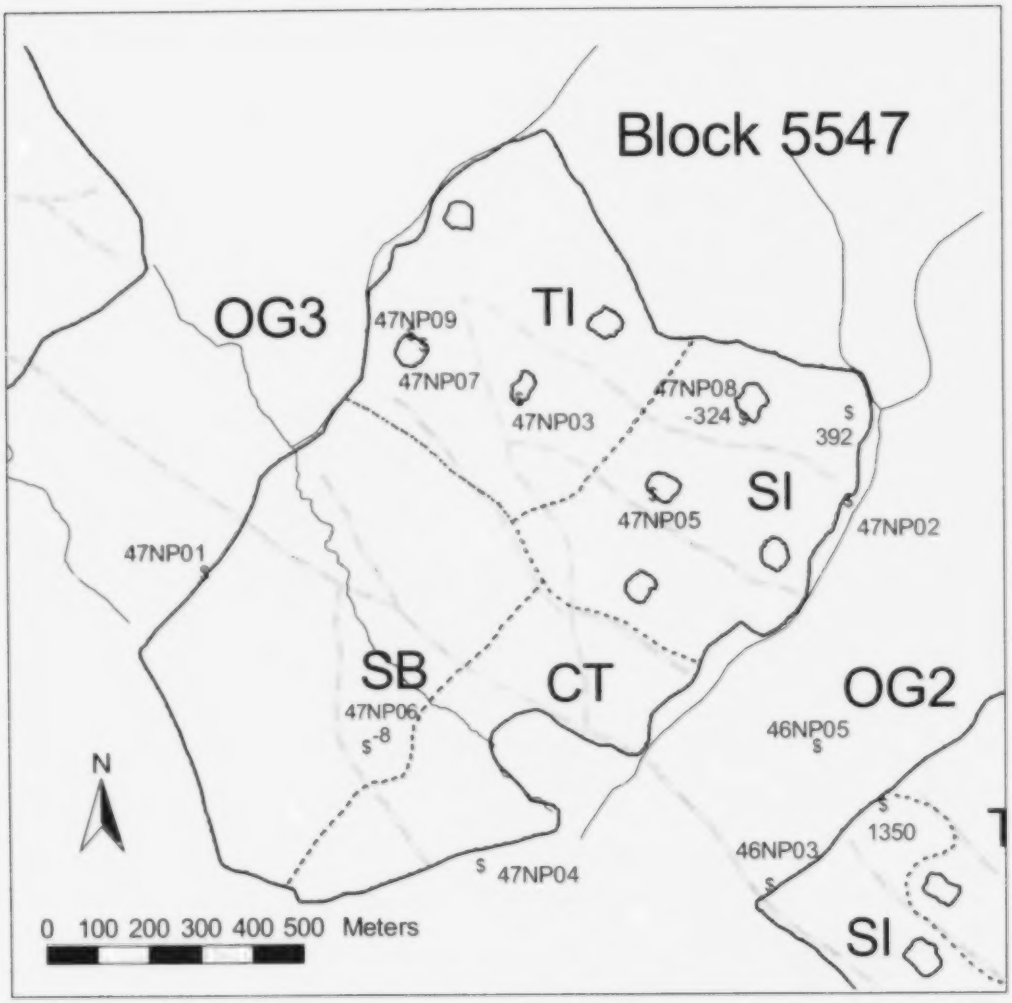

Figure 5. Locations of cavity nest sites (nest-trees) used in 1995 and 1996, and numbered stubs that had cavities present prior to 1995, in Experimental Block 5547 within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. Numbers alone indicate stubs with cavities present prior to 1995; NP numbers alone indicate nest-trees (live trees or snags) with locations in islands or continuous forest outside cutblocks approximate; and NP numbers with stub numbers indicate nest-trees (numbered stubs) that had active cavity nests in 1995 and/or 1996.

Table 2. Nest-tree type used by cavity-nesting birds in 1995 and 1996 within experimental cutblocks (Blocks 5516, 5546 and 5547), Donna Creek Forestry/Biodiversity Project. All perimeter-stubs, snags and live tree nest-tree types in the experimental cutblocks were located in tree islands.

	No. Cavities in nest-tree	Type of nest-tree	Bird Species [1] nesting in 1995	Bird Species [1] nesting in 1996	Notes
Nest-tree Plot No.					
16NP?A	2	Snag	RBNU		
16NP01	2	Dispersed Stub	TTWO and TRSW		In 2 separate cavities
16NP04	1	Dispersed Stub	BBWO and TRSW	BBWO and TRSW	Nested successively in same cavity in each year
16NP05	1	Snag	BBWO	MOBL	In same cavity
16NP06	1	Dispersed Stub	MOBL	MOBL	In same cavity
16NP07	1	Snag	MOBL	NOFL	In same cavity
16NP07B	1	Live tree		MOBL	
16NP08	1	Dispersed Stub	MOBL		
16NP10	1	Dispersed Stub	BBWO	BBWO	In same cavity
16NP11	1	Dispersed Stub		TRSW	
46NP01	1	Live Tree	BBWO		
46NP02	5	Dispersed Stub	MOBL		
46NP04	1	Perimeter Stub	TTWO		
47NP03	2	Snag	HAWO	TRSW	In same cavity
47NP05	1	Snag	BBWO	BBWO	In same cavity
47NP06	1	Dispersed Stub	MOBL	MOBL	In same cavity
47NP07	1	Snag	TRSW		
47NP08	1	Perimeter Stub		TTWO	
47NP09	2	Perimeter Stub	TTWO	TTWO	In newly excavated cavity in 1996

[1] BBWO = Black-backed Woodpecker; HAWO = Hairy Woodpecker; MOBL = Mountain Bluebird; NOFL = Northern Flicker; RBNU= Red-breasted Nuthatch; TRSW = Tree Swallow; TTWO = Three-toed Woodpecker.

the experimental blocks, nest searching was exhaustive and 100% of cavity nests were believed to be found in both 1995 and 1996. Therefore, nest-trees or cavities used by multiple species and by different species in each year could be detailed. This was not true for nests found in the continuous forest at the block perimeters and **OG** areas where some nests may have been missed.

Among the 19 nest-trees in the experimental units, 9 nest-trees were used only once for nesting and 10 nest-trees were used more than once for nesting in 1995-1996 (Table 2). Five of these 10 reused nest-trees were used by only one species in successive years, the

other 5 were used by two species in the same or successive years (Table 2). In the **CC** unit, tree swallows in 1995 and mountain bluebirds in 1996 nested in the same cavity (Nest-tree 49NP02); this cavity was situated in a stub that was retained in the unit when it was harvested in 1991, which was before the cutblock was designated as a clearcut control in 1995 (see Gyug and Corbould 2002).

4.2 Cavity Nest Monitoring

All the black-backed woodpecker (N = 3) and three-toed woodpecker (N = 2) nests in the experimental cutblocks in 1996 successfully fledged young. Four of the 5 black-backed woodpecker nests in 1995 were also known to have fledged young successfully, as did one of the three three-toed woodpecker nests. The fate of the other black-backed woodpecker nest and the two three-toed woodpecker nests in the experimental cutblocks in 1995 is uncertain since the nests were not followed closely enough to judge fledging success. Of the 8 nests situated along the old-growth forest perimeter of the blocks that were followed in either year, a dead young three-toed woodpecker was found in one of these nests. This was the only nest, of the 18 total nests that were monitored, which appeared to be unsuccessful.

4.3 Nesting Response of Cavity Nesters to Treatments

Stubs had a significant statistical effect on cavity nest numbers (Table 3). **CT** treatments were clearly different from the **SB**, **TI** and **SI** treatments since no cavity nests were ever found in the **CT** units. There were simply no nesting structures for cavity nesters to use. The stub effect was significant and positive on the presence of cavity nests. The tree-island factor appeared to have no significant effect on cavity nesting (Table 3) but this is counter intuitive since there were some cavity nests in tree islands, and there were no cavity nests in the **CT** treatments that lacked tree islands. The correct conclusion would be that the statistical size of the tree-island effect was not as large as for the stub factor, and was variable enough that it could not be shown to be statistically different from zero based on only 2 years of data with 3 block replicates. There was also a significant block effect, with far fewer nests in Block 5546 than the other blocks.

Table 3. Numbers of active cavity nests in 1995 and 1996 in each experimental treatment unit, and ANOVA test statistics for treatment factor, year and block interactions, Donna Creek Forestry/Biodiversity Project, 1995-1996.

	Number of Cavity Nests per Treatment Unit				ANOVA Test Statistics[1]				
	CT	SB	TI	SI	Effect	d.f.	MSE	F	P
Block and Year									
5516					Stubs (S)	1	9.38	**6.36**	**.02**
1995	0	6	1	3	Tree Islands (I)	1	2.04	1.39	.26
1996	0	3	1	4	S*I Interaction	1	3.38	2.29	.15
5546					Year	1	1.04	0.71	.41
1995	0	1	1	1	Block	2	7.04	**4.78**	**.02**
1996	0	0	0	0	Error	17	1.47		
5547									
1995	0	1	3	1					
1996	0	1	2	2					

[1]Three-way ANOVA with the only interaction effect tested being Stubs * Islands; d.f. = Degrees of freedom; MSE = Mean Square Error; Alpha = 0.05, with significant F in Bold.

Different species of cavity nesting birds nested in different types of habitats (Table 1). Black-backed woodpeckers only nested in the experimental treatments and not in the old-growth forests, neither **OG** areas or the adjacent continuous forest. Three-toed woodpecker nests were most common in the adjacent old-growth continuous forest, although they were also found in the tree islands and once in an **SB** treatment. Hairy woodpecker and northern flicker nests were only found in tree islands. Red-breasted nuthatches only nested in forested areas: 1 nest in each forested site type (tree island, continuous forest and **OG** area). Mountain bluebirds and tree swallows nested in the experimental cutblocks (inside and outside the tree islands), and in the **CC** units. The only cases of nesting in the **CC** units were when mountain bluebird and tree swallow nests were located in the same cavity in the only stub in Block 5549 that was not part of the study design, and when mountain bluebirds nested in a fire-created snag in a portion of the continuous forest adjacent to Block 5510 where the broadcast burn had escaped into the forest.

4.4 Nest-tree Surroundings

4.4.1 Nest Distances to Tree Islands and Old-Growth Forest

Of the 12 nests found in the forest at the perimeter of the experimental cutblocks, all but one were three-toed woodpecker nests, with the lone nest being a red-breasted nuthatch nest. Three of the three-toed woodpecker nests were situated on the immediate cutblock-forest interface, 4 were within 10 m of this interface, and 4 were between 20 and 50 m of the interface; the distance was unrecorded for one nest. This does not imply that three-toed woodpeckers prefer nesting at the perimeters of continuous forest, since only the perimeters of the old-growth forest were extensively searched for nests. The red-breasted nuthatch nest in the continuous forest was 50 m from the cutblock boundary.

Three-toed woodpeckers clearly seemed to prefer forested situations, or sites at the edge of forests, for nesting. There were 4 three-toed woodpecker nests in 3 perimeter-stubs in tree islands and only 1 three-toed woodpecker nest in a dispersed stub, which was only 35 m from the forested edge. The mean distance of the 4 nests in the 3 tree islands from continuous forest was 103 m. The mean distance of these 3 tree islands from continuous forest (52.3 m, SE = 9.0 m, N =3) was significantly lower than the mean distance from continuous forest of all other tree islands (140.1 m, SE = 18.9, N = 19; $t = 4.20$, $P < 0.001$). Therefore, three-toed woodpeckers did appear to select tree islands for nesting that were close to continuous forest, and did appear to either avoid stubs in the open altogether, or only select those close to continuous forest for nesting.

For the other three common cavity-nesting bird species (black-backed woodpecker, mountain bluebird and tree swallow) in the experimental treatments, nests of each species were regularly found both inside and outside of tree islands (Table 1). Locations of nest-trees within tree islands were only recorded for 7 of the 11 nest-trees. These nest-trees were either located on the perimeter of the tree island, or inside the tree island but within 5 m of its perimeter. No analysis of this information is possible because the location of the remaining 4 nest-trees within the tree islands was not recorded. However, based on the information that was collected, there did seem to be a preference for nesting at the perimeter of the tree islands.

The mean distance to the continuous forest from the 3 tree islands that contained the 4 black-backed woodpecker nests (164.0 m, SE = 62.4 m, N =3) was not significantly

Table 4. Mean distances to a forested habitat (continuous forest or tree islands) for cavity nests used in dispersed stubs during 1995 and 1996, and randomly selected stubs, in experimental cutblocks within the Donna Creek study area, Donna Creek Forestry/Biodiversity Project. Comparisons made using Student's t-test assuming unequal variances.

	Distance (m) to continuous forest					Distance (m) to nearest Tree Island				Distance (m) to nearest forest (continuous or island)			
	N	Mean	S.E.	t	P	Mean	S.E.	t	P	Mean	S.E.	t	P
Samples Compared													
Cavity nests in stubs	15	146.1	21.0			274.6	49.6			128.7	18.0		
Random stubs	15	139.7	24.9	0.20	0.84	249.3	56.2	0.34	0.74	89.1	19.0	1.51	0.14
Stub nest-trees[1]	8	140.5	31.0			270.9	68.2			124.3	26.1		
Random stubs	8	140.1	39.5	0.01	0.99	191.4	60.8	0.87	0.40	71.4	18.1	1.58	0.14

[1] Stubs with >1 cavity nest (within or between years) were only counted once.

different from the mean distance from continuous forest to all the other tree islands (122.4 m, SE = 18.3, N = 19; t = 0.64, P = 0.59). Black-backed woodpeckers, therefore, did not appear to select tree islands for nesting that were close to continuous forest.

The mean distance between the continuous forest and the 3 mountain bluebird nests in the 2 tree islands was 273 m, and for the 2 tree swallows nests in 2 tree islands the mean distance was 188 m. These distances were all clearly higher than the mean tree island distance from continuous forest (128.1 m, SE = 17.5, N = 22), but small sample sizes for both species limit the applicability of statistics.

When all 7 species of cavity-nesting birds found nesting in tree islands and all tree islands (excluding the single large 1.4-ha tree island which had no nests and was not part of the original experimental design) were pooled, there was no correlation between the total number of cavity nests over the 2-year period and the size of the tree islands ($r = 0.30$, $F_{(1,19)} = 1.86$, $P = 0.19$). The size range of tree islands created and considered here (0.18-0.40 ha) was probably too narrow to make much difference to these cavity-nesting birds.

There were no significant differences in the distance to continuous forest, tree islands, or the nearest forest (either continuous or tree island) for cavity nests found in stubs compared to randomly selected stubs (Table 4). When just comparing the nest-tree stubs, i.e. only using each stub once, rather than counting a stub twice if used twice for nesting,

the results were the same (Table 4). Although there were not enough samples to compare individual bird species statistically, there were no obvious correlations of distance to forest and use of stubs for nesting for any of the four common species, other than the three-toed woodpecker relationship, i.e., the apparent avoidance of stubs far from forested areas, that has already been mentioned.

4.4.2 Stub Densities, and Physical and Vegetation Characteristics

Local stub densities within a 50-m radius of all dispersed stub nest-trees (10.3 stubs/ha, N = 8, SE = 1.31) outside of tree islands was not significantly different from local stub densities from a randomly selected sample of stubs (8.8 stubs/ha, N = 8, SE = 0.96; t = 0.88, P = 0.39). Although there were not enough samples to statistically compare each bird species on its own, it appeared that black-backed woodpeckers nested in dispersed stubs with higher local stub densities (4 nests in 2 stub nest-trees with a mean of 15.3 stubs/ha near nest-trees) than randomly selected dispersed stubs. Tree swallows and mountain bluebirds had closer to average stub densities near their nest-trees (10.7 and 7.3 stubs/ha respectively).

There were no differences in the moisture regime at dispersed-stub nest-trees and at the nearest point-count stations (Table 5). Each dispersed stub nest-tree was not particularly close to its paired point-count station (mean distance between = 119 m, SE = 30 m, range = 47-310 m), so the vegetation of physical parameters could be considered independent so that valid comparisons could be made. Coverage of sub-dominant trees and of tall shrubs was very low in harvested areas in general (Gyug and Corbould 2002), and also very low around nest-trees (Table 5). No statistical comparisons could be made in coverage of sub-dominant trees or tall shrubs because these were absent at almost all nest-tree stubs, and absent at every point-count station in this analysis. There were no significant differences in vegetation cover <2-m height, except for low deciduous shrubs which had significantly higher coverage by 1.8% around stub nest-trees than around the point-count stations (Table 5).

The density of tree stumps that were >19.9-cm DSH in the 11.3-m radius plots at nest-tree stubs was significantly higher than around the nearest point-count stations (362.5 vs. 225.0 stumps/ha, Table 5). The mean DSH was not significantly different around the nest-tree stubs compared to the nearest point-count stations (Table 5). There were no snags around the point-count stations, but were a few within 25-m radius of 3 of the dispersed-stub nest-trees (Table 5). There were no significant differences in stub densities at nest-tree stubs

Table 5. Pair-wise comparison of habitat characteristics (moisture regime, vegetation cover by strata layer, stump, snag, stub and upturned root wad densities, and mean diameter at stump height [DSH]) at 1995 and 1996 dispersed stub nest-trees and the nearest point-count station to each nest-tree stub, Donna Creek Forestry/Biodiversity Project, 1995-1996. Vegetation cover and stump and root-wad densities are based on data from 11.3-m radius plots unless otherwise indicated; all habitat data collected in 1996. NC indicates data was absent for one set of the pair and t statistic was not calculated.

	At Nest-tree stubs (N = 8)		At Nearest point count stations (N = 8)		Pairwise comparison t-test statistics	
Plot measurable	**Mean**	**S.E.**	**Mean**	**S.E.**	**t**	**P**
Moisture regime:						
11.3-m radius plot	-0.32	0.35	-0.50	0.27	0.47	0.65
50-m radius plot	-0.43	0.35	-0.23	0.29	0.54	0.60
Vegetation cover (%) by strata layer						
Sub-dominant trees (>10-m ht. but <canopy ht.)						
Coniferous	0.01	-	0	-	NC	
Deciduous	0	-	0	-	NC	
Tall shrub (2 to 10-m ht.)						
Coniferous	0.15	-	0	-	NC	
Deciduous	0	-	0	-	NC	
Low shrub (<2-m ht.)						
Coniferous	1.11	0.35	0.66	0.17	1.19	0.27
Deciduous	4.34	1.16	6.11	0.93	**2.96**	**0.021**
Other ground cover (<2-m ht.)						
Fireweed	20.29	2.56	20.06	5.27	0.04	0.97
Grass	8.58	4.81	4.40	2.39	0.99	0.36
Other herb	7.69	1.94	10.00	2.85	1.54	0.17
Moss	2.68	0.93	4.13	2.38	0.73	0.49
Other habitat features						
Cut tree stumps >19.9-cm DSH (number/ha)	362.5	27.54	225.0	30.25	**3.10**	**0.008**
Mean DSH of cut tree stumps (cm)	38.3	1.10	38.2	2.26	0.06	0.48
Snags >15-cm DBH [a] (number/ha)	2.55	1.36	0	-	NC	
Stubs >15-cm DBH [b] (number/ha)	16.55	2.31	12.73	3.47	1.43	0.10
Upturned root-wads (number/ha)	9.4	4.57	96.9	15.98	**4.95**	**0.002**

[a] Snag densities based on 11.3-m radius plots for point-count stations, but on 25-m radius plots for nest-tree stubs.

[b] Stub densities based on counts in 25-m radius plots for point-count stations, but on GPS-traverse location data in 25-m radius for nest-tree stubs (since stub counts appeared to have only been recorded for 50-m radius plots at NP plots around dispersed stubs), and include nest-tree stub.

compared to point-count stations (Table 5). The density of upturned root wads around each nest-tree was significantly lower than around the nearest point-count stations (9.4 vs. 96.9 root wads/ha, Table 5). There were only 3 root wads in total in the 11.3-m radius plots around the 8 dispersed-stub nest-trees, compared to 31 root wads around the 8 point-count stations.

4.4.3 Interspecific and Intraspecific Nest Spacing

There were no apparent limits on the proximity in which secondary cavity-nesting birds (mountain bluebirds and tree swallows) would nest to primary cavity-nesting birds (woodpeckers). In 1995, three-toed woodpeckers and tree swallows nested in 2 different cavities in the same stub at the same time (16NP01). Northern flickers and mountain bluebirds also nested in different nest-trees in the same tree island in 1996 (16NP07 and 16NP07B), as did three-toed woodpeckers and tree swallows in 1995 in a different tree island (47NP07 and 47NP09). However, there did appear to be spacing within the secondary-cavity nesting species and within the primary cavity-nesting species groups.

Within both 1995 and 1996, no woodpecker nest was closer than 200 m to another woodpecker nest in, or adjacent to, the experimental units (Figures 6-7). The only woodpecker nests that might have been closer than 200 m were the 1995 three-toed and black-backed woodpecker nests at the north edge of the **SB** unit of Block 5516 (Figure 6). However, since the exact location of the nest in the continuous forest was not known, the distance between nests cannot be computed exactly.

The only block with multiple mountain bluebird nests in either 1995 or 1996 was Block 5516. Nests were spaced at a minimum of 300 m between nests. The only block with more than one tree swallow nest present was Block 5516 in 1995 and 1996. The minimum distance between nests was just over 500 m in each year. Tree swallows also did not nest closer than 300 m to any active mountain bluebird nests except in Block 5516, where nests were within 75 m of each other (16NP04 and 16NP08). However, the tree swallows only established the nest late in June after the cavity had been vacated by black-backed woodpeckers, and it was not clear if the mountain bluebirds had also finished nesting by that time.

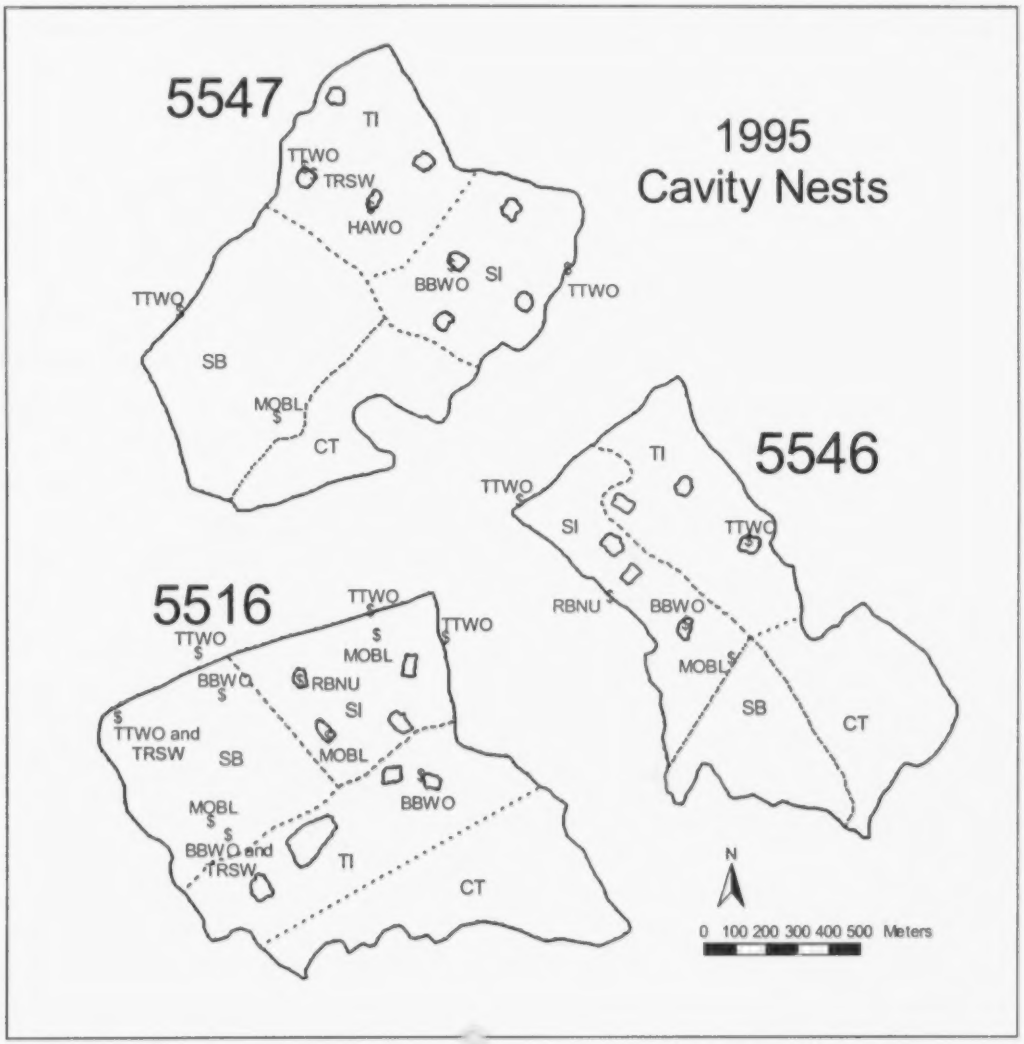

Figure 6. Cavity nest locations and bird species using nests in 1995 in Experimental Blocks 5516, 5546 and 5547, Donna Creek Forestry/Biodiversity Project. Block 5516 has been moved in this map in order to fit on the page and maintain an appropriate scale for viewing; proximal orientation of Blocks 5546 and 5547 are spatially correct.

Species Codes: BBWO = black-backed woodpecker, HAWO = hairy woodpecker, MOBL = mountain bluebird, NOFL = northern flicker, RBNU = red-breasted nuthatch, TRSW = tree swallow, TTWO = three-toed woodpecker.

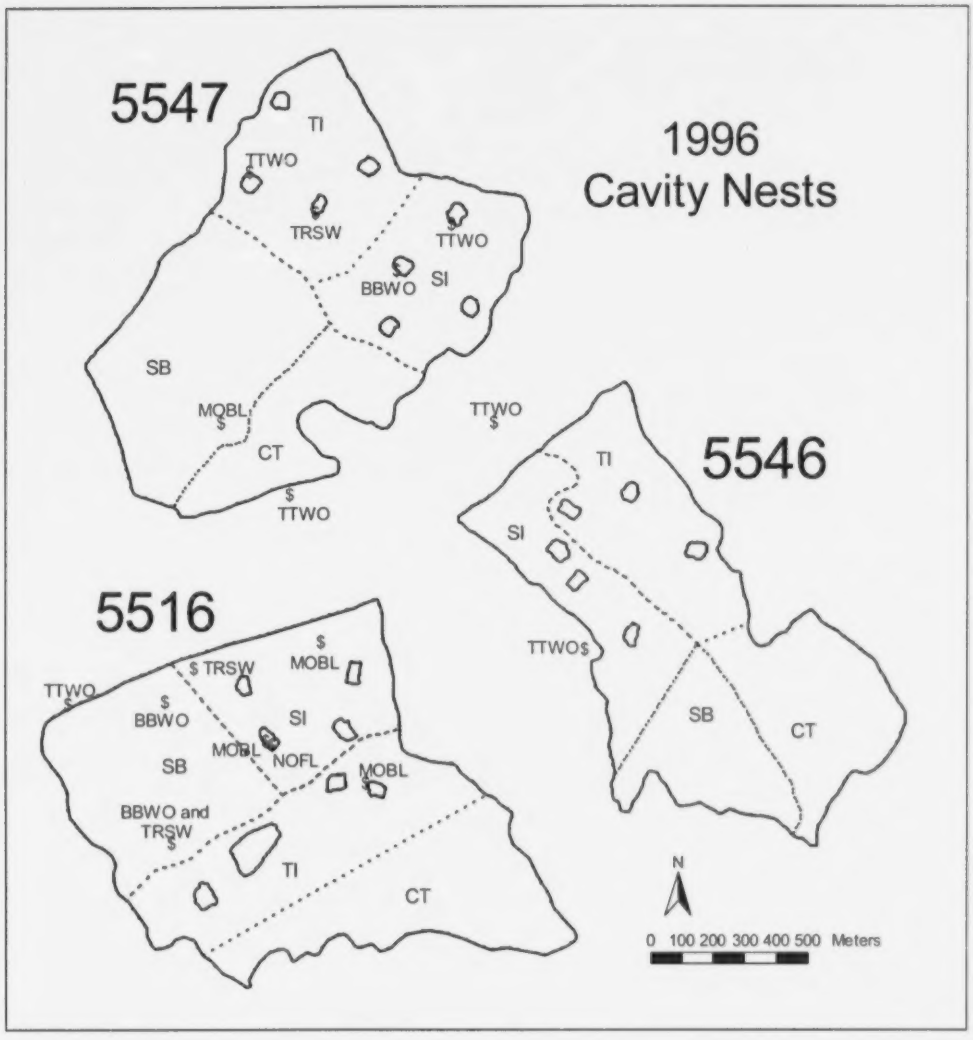

Figure 7. Cavity nest locations and bird species using nests in 1996 in Experimental Blocks 5516, 5546 and 5547, Donna Creek Forestry/Biodiversity Project. Block 5516 has been moved in this map in order to fit on the page and maintain an appropriate scale for viewing proximal orientation of Blocks 5546 and 5547 are spatially correct.

Species Codes: BBWO = black-backed woodpecker, HAWO = hairy woodpecker, MOBL = mountain bluebird, NOFL = northern flicker, RBNU = red-breasted nuthatch, TRSW = tree swallow, TTWO = three-toed woodpecker.

Table 6. Number and type of cavity nest-trees in each experimental cutblock including nest-trees with active nests in 1995-1996, as well as stubs with cavities that were excavated prior to 1995, but were not used for nesting in 1995 or 1996, Donna Creek Forestry/Biodiversity Project, 1995-1996.

	Experimental Block			
Treatment unit and stem type	**5516**	**5546**	**5547**	**Totals**
Cavity nest-trees (1995 & 1996)				
CT	0	0	0	0
SB - Dispersed Stub	4	1	1	6
TIh	0	0	0	0
TIi				
Perimeter-Stub	0	1	1	2
Snag	1	0	2	3
Live Tree	0	0	0	0
SIh - Dispersed Stub	2	0	0	2
SIi				
Perimeter Stub	0	0	1	1
Snag	2	0	1	3
Live Tree	1	1	0	2
Stubs with cavities (pre 1995)				
SB - Dispersed Stub	2	0	0	2
SIh - Dispersed Stub	4	1	1	6
SIi - Perimeter-Stub	0	1	0	1

4.5 Nest-tree Characteristics

4.5.1 Type, Species and DBH of Nest-trees

In the experimental cutblocks, 11 of the 19 nest-trees were dispersed stubs (Table 6). All cavity nests outside of tree islands were in dispersed stubs. There were no nests in the **CT** units or in the clearcut portion of the **TI** (**TIh**) units, both these units had no stubs or tree-island stems present. Within tree islands, all island stem types were used: snags (6 of 11 nest-trees), live trees (2 of 11 nest-trees) and perimeter-stubs (3 of 11 nest-trees).

None of the 11 dispersed stub nest-trees were lodgepole pine, although at least 284 lodgepole pine stubs had been created (18.7% of stubs for which species data is available; see Gyug and Corbould 2002). Five nests were in spruce stubs and 6 nests were in balsam stubs. The only nest in Block 5549 was in a balsam stub as well. Block 5549 was not originally part of the study design, therefore feller-buncher operators had not been specifically told not to create stubs. The feller-buncher operator may have seen a cavity or

Table 7. Mean diameter (cm) at breast height (1.3 m, DBH) of nest-trees, by stem type, tree species and location, with active cavity nests in 1995-1996 , and the DBH descriptive statistics (mean, standard error and range) for all stubs ≥15-cm DBH (from Gyug and Corbould 2002), Donna Creek Forestry/Biodiversity Project. All data collected during nest plot and stub assessments in summer 1996. Mean DBH not given when no nest-trees in that category, SE only calculated when N>3, and NA indicates data not available for that nest-tree.

	Experimental cutblocks		Clearcut controls		Continuous forest		Totals for All Habitats			
								DBH		
Stem type and species	N	Mean DBH	N	Mean DBH	N	Mean DBH	N	Mean	SE	Range
Cavity nest-trees (1995-1996)										
Live tree										
Balsam	2	43.4	0		0		2	43.4		27-60
Pine	0		0		0		0			
Spruce	0		0		5	39.8	5	39.8	3.75	28-49
Snag										
Balsam	5	37.2	0		2	40.2	7	38.1	2.49	30-50
Pine	1	30.6	0		3	36.5	4	35.0	2.39	30-40
Spruce	0		0		3	41.9	3	41.9		36-49
Unknown	0		0		1	NA	1	NA		
Stub										
Balsam	6	37.4	1	44.9	0		7	38.5	2.61	27-48
Pine	0		0		0		0			
Spruce	5	39.3	0		0		5	39.3	4.09	27-48
All measured stubs										
Balsam							733	32.5	0.39	15 - 74
Pine							284	31.3	0.46	15 - 58
Spruce							485	39.0	0.50	15 - 69

nest hole in this one tree or snag and decided to retain the wildlife feature by making it into a stub. This lone stub in a **CC** unit was used for nesting in 1995 by tree swallows and in 1996 by mountain bluebirds.

The mean DBH for spruce stubs used as nest-trees in 1995 and 1996 was almost identical to the mean DBH of all spruce stubs (39.0 vs. 39.4 cm DBH respectively, Table 7) and were not significantly different ($t = 0.07$, $P = 0.47$). The balsam stubs used for nest-trees were not significantly larger in diameter than the mean balsam stub diameter (38.5 vs. 32.5 cm DBH respectively, Table 7, $t = 2.25$, $P = 0.06$). However, all but 1 of the 7 balsam stubs used for nesting was larger than the mean for all balsam stubs. Although there was

no statistical significance, likely due to the small sample size of only 7 balsam stubs used for nesting, it did appear that larger balsam stubs than average were used as cavity nests.

4.5.2 Decay Characteristics of Nest-trees

Within the experimental cutblocks, the 10 nest-trees (1 live tree, 3 snags and 6 stubs) used by *Picoides* woodpeckers (all of which are primary cavity excavators: black-backed woodpecker, three-toed woodpecker and hairy woodpecker) in 1995 and 1996 had decayed heartwood (6 rated very soft, 3 rated soft, and 1 rated spongy) and relatively hard sapwood (6 rated hard and 4 rated spongy). The single nest-tree rated with spongy heartwood (i.e., heartwood that remains intact, somewhat flexible and can be shaved with a pen knife) was a live tree with the nest at 8.6-m height and only 1-cm of heartrot was found where the core was taken. However, the heartrot at the nest site was probably more extensive than where the sample was taken with a wood corer, so the spongy-rated heartwood may be an underestimate of the heartrot at the cavity location. Some of the decay fungi in Donna Creek causing this heart rot were identified as *Phellinus pini* and *Fomitopsis pinicola*. All but one of these nest-trees had >75% of bark intact. None of these *Picoides* primary excavator nests were in naturally occurring cavities, all had been excavated by birds.

Within the experimental cutblocks, there were 8 nest-trees (1 live tree, 2 snags and 5 stubs) used only by secondary cavity nesting birds including mountain bluebirds and tree swallows, and a northern flicker using a nest in a cavity that was used in the previous year by a mountain bluebird. Three of the nests were in natural cavities (i.e., not excavated by birds), one each in a live tree, a snag and a stub. Although the openings of the cavities may have been created naturally, it does not mean that the inside of the cavity had not been enlarged and made useable for nesting by a primary-excavating bird. All 8 nest-trees had very decayed heartwood (rated very soft), and sapwood that ranged from hard to soft. Since these secondary cavity nesters may use cavities for many years, the sapwood may be expected to soften over the years after possibly being relatively hard when the cavity was first created (e.g., excavated by a primary cavity nester).

No detailed decay data was available for Nest-tree 16NP?A in the experimental cutblocks. It was identified as a snag, possibly broken-off at 8.6 m height, in a tree island that was used by a nesting red-breasted nuthatch, a weak excavator that can only excavate its own nest in relatively soft wood or use pre-existing cavities. The WTC was rated as 4+ and recorded as being in an "advanced" decay stage, indicating the tree had probably been dead for a few years and was generally soft.

For the 15 nest-trees outside the experimental cutblocks, the same trends in decay and nesting were evident; no decay data was available for 4 of these nest-trees. For the 11 decay-assessed nest-trees, the only nest-tree used by secondary cavity nesters was the lone stub in Block 5549. This stub was in an advanced decay state with heartwood rated very soft and sapwood rated soft. The remaining 10 nest-trees were used by three-toed woodpeckers, a primary cavity excavator. Seven of these 10 had hard sapwood, and all had heartrot present. The extent of heartrot at nest height was, however, difficult to judge from a core sample at breast height. The higher the nest height was, the more likely the core at breast height was to receive a harder heartwood rating. In trees where the cavity nest height was above 7 m, heartwood in the stem bole at breast height was rated hard or spongy. Where cavity nests were lower than 7 m, heartwood was rated soft or very soft.

4.6 Nest Cavities

Cavities in stubs used for nesting in 1995 and 1996 were mostly in the top third of the stubs at heights of 2.5 to 4 m (69% of 13 nests), with the remainder (31%) in the middle third of the stubs at heights of 1.5 - 2 m. The mean cavity entrance height on stubs for cavities that were used in 1995 and 1996 was 2.87 m (S.E. = 0.25, N = 11, with 4 unrecorded). Cavities used for nesting in 1995 and 1996 in live trees and snags (N = 24), were more evenly spread over the height of the stem, with the largest portion (46%) in the middle third, and fewer (29%) in the top third, and the bottom third (25%). Cavity entrance heights on live trees and snags ranged between 2.9 and 15.6 m with a mean nest height of 8.7 m (S.E. = 1.2, N = 12 since cavity entrance heights were only measured on 12 of 24 snags and live trees).

Cavity entrance dimensions were only measured at 14 cavities, which accounted for less than half of the cavities actually used in 1995 and 1996. Cavity orientations were also recorded at 14 cavities, but not necessarily the same cavities at which entrance dimensions were recorded. Cavity entrance sizes ranged between 4.0 and 8.2 cm, with 11 between 4.0 and 5.5 cm, with the last 3 between 7.5 and 8.2 cm. Cavity entrances were mostly circular, so only one dimension (the diameter) was usually recorded. The orientations of cavity entrances were in every possible direction, with the only slightly favoured direction appearing to be southwest, with 5 of the 14 cavities facing that direction. However, 5 also faced north, northeast and east, so it did not appear that any particular cavity-entrance orientation appeared to be highly favoured.

4.7 Other Possible Cavity-Nesting Birds

Cavity-nesting bird species not found nesting in the study area but observed during point-count surveys during the breeding period (Gyug 1997) included American kestrel (*Falco sparverius*), boreal chickadee (*Poecile hudsonica*), brown creeper (*Certhia americana*), winter wren (*Troglodytes troglodytes*), northern hawk-owl (*Surnia ulula*), boreal owl (*Aegolius funereus*), and northern pygmy-owl (*Glaucidium gnoma*).

A pair of American kestrels were active daily inside the **SB**, **TI** and **SI** treatment units of Blocks 5516, 5546 and 5547 throughout 1995 but no nest was found in the cutblocks. They probably nested in the area, but the location of any nest was unknown. In 1993, one possible American kestrel nest was found in the **SI** treatment unit of Block 5546, 130 m from the forest and 27 m from a tree island (Gyug and Summers 1995). The exact location was not recorded, but the nest was probably in a stub since there were no snags or live trees that would be outside tree islands in the **SI** treatment of Block 5546.

Boreal chickadees and brown creepers were found in all three **OG** areas in 1995 and 1996 during point-count surveys (Gyug 1997), and probably nested in one or more of these areas. Boreal chickadees were detected only 3 times in the 1993 surveys, and were not thought to breed in the **OG** areas sampled that year (Gyug and Summers 1995). Boreal chickadees and brown creepers were never detected in the experimental cutblocks. Mountain chickadees (*Poecile gambeli*) were seen in late-May 1993 in , or adjacent to, the tree islands of Block 5516 (Gyug and Summers 1995), but were not detected on the surveys in 1995 and 1996. They probably did not breed in the area.

Winter wrens were found in all three **OG** areas in 1995 and 1996 (Gyug 1997) and probably nested in one or more of these. Winter wrens were occasionally detected (3 of 7 point-count visits at Station 46TI2) in Isl 47-6 of Block 5546. This tree island was only 35 m from the continuous forest, and straddled a stream. Winter wrens may have been using this tree island as part of a larger breeding territory that was mostly in the old-growth forest adjacent to Block 5546.

At least one boreal owl was present in the old-growth forest in the vicinity of Block 5516 during the spring of 1995 (from 14 June onward; Joy and van den Driessche 1995), and may have been nesting in the area. However, it did not nest within the experimental cutblocks. A northern pygmy owl was heard regularly throughout the breeding season of 1995 in the forest near clearcut control Block 5550, and may have been breeding in the area (Joy and van den Driessche 1995). Northern hawk-owls and northern pygmy-owls

were detected only once each during breeding bird point counts in 1995 and 1996 (Gyug 1997). Since northern hawk-owls are diurnal and northern pygmy-owls are crepuscular (most active at dawn and dusk), both species would likely have been detected on more than one occasion if either were breeding in close proximity to the experimental cutblocks.

4.8 Effects of Blowdown in Tree Islands on Birds

There were no obvious differences in the general breeding bird composition in Isl 47-1 and 4 (low stem retention) compared to Isl 47-6 and 8 (high stem retention) that might be attributable to the level of blowdown present. Only 5 species were detected commonly in all these islands, and occurred more than 30 times in total on the 56 total replicated point counts conducted in these tree islands (1 point in each island counted 7 times in both 1995 and 1996, see Gyug 1997). The most abundant species that occurred relatively equally in all islands were Wilson's warblers (*Wilsonia pusilla*; 69 occurrences), followed by dark-eyed juncos (*Junco hyemalis*; 40 occurrences), and chipping sparrows (*Spizella passerina*; 36 occurrences). American robins (*Turdus migratorius*), and yellow-rumped warblers (*Dendroica coronata*) were detected more commonly in the tree islands where there had been less blowdown. American robins were detected 28 times in Isl 47-6 and -8, and only 8 times in Isl 47-1 and -4. Yellow-rumped warblers were detected 22 times in Isl 47-6 and -8, and only 10 times in Isl 47-1 and -4.

Cavity-nesting birds were recorded 16 times on point counts in 1995 and 1996 in the two tree islands that had high stem retention (Isl 47-6 and 8), and 18 times in the islands that had relatively low stem retention (Isl 47-1 and 4). Two species of cavity-nesting birds were found only in high-retention tree islands: black-backed woodpeckers were recorded 15 times and a red-breasted nuthatch was recorded once. Black-backed woodpeckers nested in Isl 47-6 in both 1995 and 1996.

Four species of cavity-nesters were only recorded in the low-retention tree islands. Three-toed woodpeckers were the most often recorded species (8 detections) followed by hairy woodpeckers (5 detections) and tree swallows (4 detections). Both hairy woodpeckers and tree swallows nested in these islands: hairy woodpeckers nested in Isl 47-4 in 1995, and tree swallows nested in the same island in 1996, and also in Isl 47-1 in both 1995 and 1996. There was a single observation of an American kestrel in Isl 47-4, as well as an observation of 2 kestrels (possibly a pair) overhead at another time.

5.0 DISCUSSION

5.1 Potential Numbers of Nest-tree Stubs

All the stubs used for cavity nests in the Donna Creek sites had heartwood decay classes of very soft or soft. For *Picoides* woodpeckers that excavate their own nests, sapwood was hard to spongy, but not soft. Sapwood decay condition was variable for secondary nesters, and probably depended largely on the time since the original cavity had been excavated, or how it had been created for natural cavities. Not all snag or live-tree nest-trees were rated with soft heartwood, but this may have been because core samples were not taken close enough to the actual cavity sites.

The percentage of stubs in the 20% decay-assessed stub sample with decay characteristics that would make them suitable for cavity excavation by *Picoides* woodpeckers, i.e., with soft or very soft heartwood and relatively hard or spongy sapwood, varied by tree species and diameter (Figure 8, data from Gyug and Corbould 2002). The percentage of suitable stubs increased from 2% to 4.2% as the diameter of the stub increased above 35 cm DBH, and even higher to 12.5% for stubs with DBH >45 cm. Spruce stubs would be considered just as likely to be suitable for primary cavity excavation as balsam stubs. However, only a very low percentage of pine stubs would be considered useable, although this may have been because there were very few large pine stubs.

Overall only 7.6% of the decay-assessed stubs would be judged immediately suitable for cavity nest excavation by *Picoides* woodpeckers. Since the 20% sample of stubs that were decay-assessed was considered a representative sample of the general stub population (Gyug and Corbould 2002), then based on the 2,133 stubs created in the experimental cutblocks, it would be expected that about 162 stubs might be considered immediately suitable for primary cavity excavation by *Picoides* woodpeckers.

Based on the spacing of woodpecker nests in this study (>200 m between adjacent nests), the distance between adjacent woodpecker nests may be a factor that limits which nest-trees can be used nesting in any given year, above and beyond which stubs, snags or live trees in tree islands may be actually suitable for nesting. This may also hold true for secondary cavity-nesting birds, and will be discussed below for each secondary cavity-nesting species.

Only stubs >27 cm DBH were used for cavity nesting in 1995 and 1996, despite the fact that there were an estimated 600 stubs (28.4% of 2,133 stubs) smaller than that available in the experimental units. Only in the bigger stubs was there likely to be heartrot that would provide opportunities for primary cavity excavation.

Phellinus pini is a major heart rot of living trees which quickly dies once the tree dies (Allen et al. 1996). From this project's stub decay data (Gyug and Corbould 2002), it

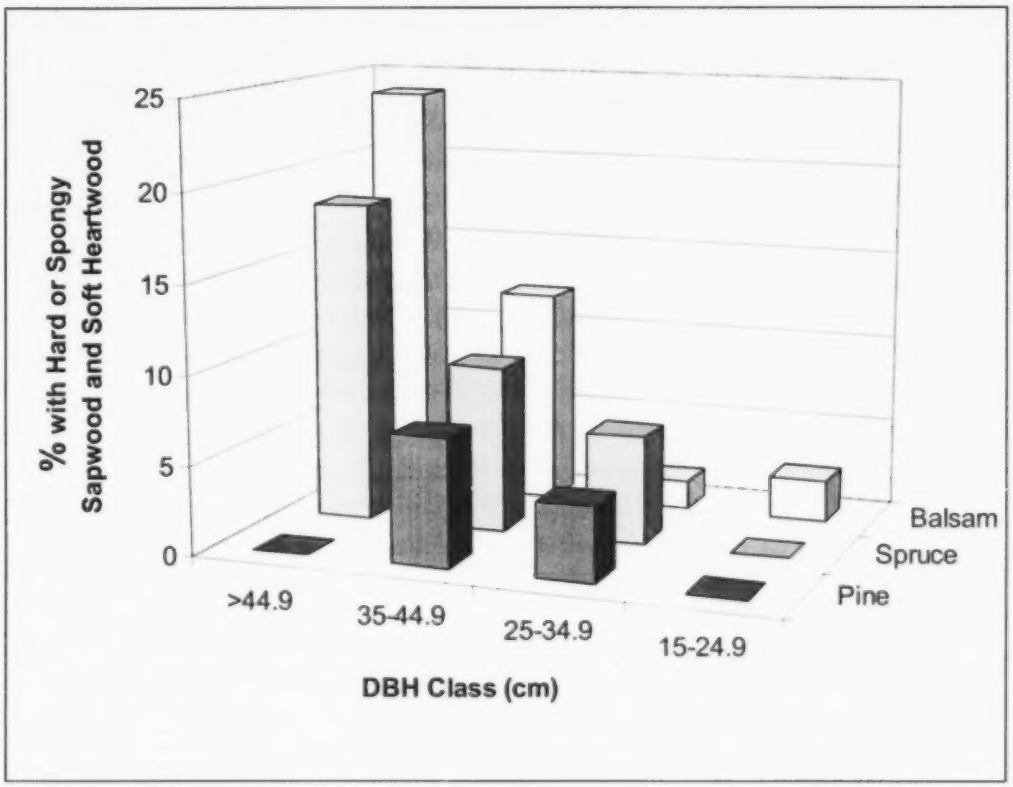

Figure 8. Percentage of stubs ≥15-cm diameter at breast height (DBH) considered suitable for primary cavity excavation by species and DBH class in the 20% decay-assessed stub sample, Donna Creek Forestry/Biodiversity Project, 1996. Stubs were considered suitable for primary cavity excavation if the stem heartwood was soft (Class 3 or D) and sapwood was hard or spongy (Class 1 or 2). Stub decay data is from Table 13 of Gyug and Corbould (2002).

would appear that once a stub is cut the entire stub will begin to rot and soften, thus heart rots will not establish in preference to other rots. Therefore, further recruitment of suitable stems in the class preferred by primary cavity excavators, i.e. decayed heartwood and sound sapwood, would not be expected after the stub's creation. However, weaker excavators such as chickadees and nuthatches may begin to excavate into these softer stubs, as would northern flickers that seem to prefer excavating in softer wood.

5.2 Vegetation Differences around Dispersed-Stub Nest-Trees

The largest vegetation differences around nest-trees were in the forest to non-forest comparisons, and these are discussed separately for each cavity-nesting species below. Comparing just the dispersed stubs used as nest-trees, there were also some significant differences in vegetation. However, it is difficult to imagine how a 1.8% difference in low deciduous woody shrub cover could affect the use of stubs by cavity-nesting birds, particularly when those species would use nest-trees inside tree islands where the vegetation was quite different.

It is not known why there might have been a significant difference in densities of stumps and upturned root wads around nest-tree stubs compared to point-count stations. If the densities of stumps, root wads, stubs and snags are summed to try to estimate the original densities of tree stems before harvesting, then the densities appear more similar (391 stems around the nest-tree stubs, and 335 stems around the point-count stations) than if based on stump counts alone. It would appear that there were few differences in site treatments, i.e., degree of mechanical disturbance, that would account for the differences around nest-tree stubs compared to point-count stations since most of the stubs were in Block 5516 where there were no mechanical site treatments (Gyug and Corbould 2002). Longer-term data that would include more stub nest sites in the sample might help to determine if there were significant reasons why there should be such differences in stump or root wad densities, or if the differences were due only to the small (N = 8) sample size.

5.3 Effects of Blowdown in Tree Islands on Birds

The different frequency of observations of cavity-nesting birds in tree islands with different stem-retention levels appear to be directly related to the occurrences of nests in the tree islands, rather than the degree of fallen stems: where there were nests, the associated bird species was recorded fairly often on the point counts. We do not know if occurrence of nests in these islands may be due to blowdown and consequent canopy openness, or for other unknown reasons. The opening of the canopy by fallen stems may

have allowed the use of tree islands by tree swallows as they forage widely in open spaces but were never seen within the closed canopy old-growth forest (**OG** areas) in the Donna Creek project (Gyug 1997).

Since stem retention levels were only estimated in these 4 tree islands within the experimental blocks, only a very small sample size is available and no firm conclusions should yet be drawn about the effect of stem retention on different species of cavity-nesting birds. However, the conclusion can be drawn that residual tree islands can be very useful to cavity-nesting birds even with stem retention rates that were estimated as low as 27% (Gyug and Corbould 2002). Approximate estimations of the extent of blowdown (or conversely, stem retention) in each tree island in the experimental cutblocks might allow for conclusions to be drawn about the effects on cavity-nesting and other bird species.

5.4 Mitigative Values of Stubs and Tree Islands

The mitigation values of stubs and tree islands to cavity-nesting birds in clearcut cutblocks is indisputable: without either stubs or tree islands, there were no cavity nests in cutblocks. Without some form of mitigation, the short-term effects of clearcutting old-growth forests on cavity-nesting species is quite drastic, and quite opposite the effects of wildfire where certain cavity-nesting species can be quite common (Schieck and Hobson 2000). Hobson and Schieck (1999) identified the time immediately following disturbance as the time when bird communities in post-fire and post-timber harvesting stands differed most dramatically, and the time for which strategies need to be developed to compensate for those differences. Stubs and tree islands in clearcut areas provide an effective mitigation of those effects for some of the species most affected by timber harvesting. Following is a discussion of each species or group of species of cavity-nesting birds found at Donna Creek.

5.4.1 *Picoides* Woodpeckers

For *Picoides* woodpeckers (black-backed woodpecker, three-toed woodpecker and hairy woodpecker), the dispersed stubs and the perimeter-stubs, snags and live trees in tree islands provide both nesting and foraging sites. Cavities are excavated in these standing stems for nesting sites, and *Picoides* woodpeckers feed upon the wood-boring beetles, bark beetles and other insects that live on or in these standing stems.

Black-backed woodpeckers nested in both dispersed stubs and in tree-island stems throughout the experimental blocks at Donna Creek in 1995 and 1996: a mean of 4 nests

per year were observed (5 in 1995 and 3 in 1996). The same number of nests were observed in 1993 (1-2 years after logging) when one confirmed black-backed woodpecker nest and 3 other possible nests were found (Gyug and Summers 1993). Black-backed woodpeckers are specialists in recently burned stands in the boreal forests across Canada and the montane coniferous forests of the inland Pacific Northwest (Dixon and Saab 2000). They may also colonize areas of bark beetle outbreaks (Dixon and Saab 2000).

The stubs and tree islands in the Donna Creek study area appeared to adequately imitate a post-fire habitat as the experimental units were colonized by black-backed woodpeckers. Since they did not nest in continuous forest at Donna Creek, the stubs and tree islands appeared to create a suitable habitat in the harvested cutblocks that would not have otherwise existed in conventional clearcuts. It was therefore not surprising that they used all areas of the Donna Creek experimental units, no matter what the distance was from continuous old-growth forest.

The principal nest predators of black-backed woodpeckers appear to be northern flying squirrels (*Glaucomys sabrinus*) and red squirrels (*Tamiasciurus hudsonicus*) (Dixon and Saab 2000). Red squirrels were absent from the Donna Creek experimental cutblocks in winter but were common in the adjacent **OG** control areas (Corbould and van Hengeveld 1998). However, one red squirrel nest was found in a cavity in a live tree in a tree island (Isl 46-3, Joy and van den Driessche 1995) in which no cavity-nesting birds nested in either 1995 or 1996. Since red squirrels were not recorded on breeding bird point counts (Gyug 1997), we do not know how common red squirrels may have been in other tree islands.

Red squirrels would be expected to recolonize the harvested areas of the experimental units as well as all of the tree islands when cone crops would be available on the regenerating trees, which could be as little as 14 years after clearcutting (Gyug 2000, Sullivan et al. 1994). Northern flying squirrels are obligate users of forest (Wells-Gosling and Heaney 1984) but may recolonize lodgepole pine stands as young as 20 years old (Ransome and Sullivan 1997). At these stages, there may be declines of black-backed woodpeckers or other cavity-nesting birds that may be directly due to the abundance of squirrels on the sites.

Observed nest densities of black-backed woodpeckers in recently burned stands are between 2 and 12.5 pairs/100 ha (Bock and Lynch 1970, Dixon and Saab 2000,Taylor 1979). Observed densities at Donna Creek would be 2.0 nests/100 ha in 1995 and 1.2

nests/100 ha in 1996, based on a total area of 251.8 ha (sum of the **SB**, **TI** and **SI** unit areas, i.e., the units where there is potential nesting habitat). This observed nest density is in the range of the nest densities quoted in the literature, although differences in survey methods and reporting units do complicate direct comparisons (Dixon and Saab 2000)

For black-backed woodpeckers, stubs and tree islands are probably necessary to mitigate the effects of clearcutting forested stands. The post-fire habitats, with their temporary and ephemeral superabundance of foods (bark-boring beetles), that appear essential to black-backed woodpeckers are not imitated by clearcut cutblocks, except with mitigation efforts such as stub or tree-island retention. Black-backed woodpeckers appear to be a highly irruptive species, with the ability to maintain populations by using these temporary habitats. Without such mitigation efforts, and in the absence of wildfires due to fire suppression initiatives, large populations of black-backed woodpeckers will likely not re-establish or flourish.

At Donna Creek, 50% of the dispersed stubs had recent woodpecker feeding sign (Gyug and Corbould 2002), most of which would have been from black-backed woodpeckers since hairy woodpeckers and three-toed woodpeckers were rarely observed outside of the continuous forest or tree islands. During behavioural studies at Donna Creek, 89% of black-backed woodpeckers' time was spent on stubs, although most of that appeared to be associated with the nest sites used, rather than feeding (Joy and van den Driessche 1998). Since black-backed woodpecker territories are only 61-124 ha in size (Dixon and Saab 2000), much of the feeding requirements of the black-backed woodpeckers nesting in the Donna Creek study units may have been met by feeding on insects in stubs.

Three-toed woodpeckers clearly preferred forested sites for nesting, either in tree islands close to continuous forest, or in continuous forest adjacent to the cutblocks. During behavioural surveys, they were detected most often in tree islands (68%) followed by continuous forests (32%) (Joy and van den Driessche 1998). They were seen most often on live trees in tree islands (84%), and only rarely on stubs at the perimeter of tree islands (13%) (Joy and van den Driessche 1998). They were never detected on stubs in the **SB** or **SI** treatments during the behavioural surveys (Joy and van den Driessche 1998), and were never detected outside of tree islands in the breeding bird point counts (Gyug 1997). In 1993, 1-2 years after timber harvesting, no three-toed woodpeckers were noticed nesting in any of the tree islands with 86% of the three-toed woodpecker detections in the **OG** areas, 11% in tree islands and 3% (1 observation) outside of tree islands in the **SIh** treatment, but not noted on a stub (Gyug and Summers 1995).

To mitigate the effects of clearcut logging on three-toed woodpeckers, dispersed stubs at densities of 5-10 stubs/ha will be of limited usefulness and tree islands will be essential. However, even tree islands alone would not appear to be sufficient, since the only tree islands used for nesting were very close to continuous forest (all within 65 m), and the tree islands were almost certainly just part of a larger foraging territory in the continuous forests. It is not known whether this preference is for security from some potential predators, or to maximize the amount of feeding opportunities near to the nest site.

Since only 1 hairy woodpecker was found nesting in 1 tree island, any conclusions about the use of stubs and/or tree islands by hairy woodpeckers cannot be drawn from this data. Hairy woodpeckers were similarly uncommonly found on breeding bird point-count surveys in the Donna Creek study area, as they were only detected 16 times: 7 observations were in tree islands, 5 in continuous forest and 4 in harvested areas (Gyug 1997). No hairy woodpeckers were detected on behavioural surveys in 1995 (Joy and van den Driessche 1998).

5.4.2 Secondary Cavity Nesting Birds

Tree swallows were not very common at the Donna Creek study area (3 nests/yr; 1.2 nests/100 ha in **SB**, **SI** and **TI** units) compared to densities at other study areas. Observed densities of tree swallows in other study areas have, at the extreme, been up to 1,750 nests/100 ha in a hayfield in Ontario (28 nests in 2.2 ha; Mitchell and Robertson 1996) with a defended area around a nest of only 15 m radius (Robertson and Gibbs 1982). Clearly tree swallows at Donna Creek are well below potential nest densities observed in other habitats. This may be due to a lack of high quality foraging habitat rather than a lack of nesting opportunities. However, nesting opportunities may be limited at Donna Creek as well, even though there seemed to be surplus cavities, since in both 1995 and 1996 breeding pairs of tree swallows nested in a cavity only once the black-backed woodpecker young had fledged from a cavity in late June.

Mountain bluebirds were not very common at Donna Creek study area (4-5 nests/yr; average 1.8 nests/100 ha in **SB**, **SI** and **TI** units) compared to other study areas. Estimates of breeding density for other areas include 75 birds/100 ha in Wyoming aspen forest (Salt 1957), 37-45 birds per 100 ha in Wyoming (Finzel 1964), and 38 pairs/100 ha in burned Sierra Nevada conifer forest (Bock and Lynch 1970). For eastern bluebirds, mean nearest neighbour distance was 70 m even though nest boxes were super-saturated with a 30-m

spacing (Gowaty and Bridges 1991), and mountain bluebirds may have similar intraspecific spacing requirements.

Within British Columbia, primarily in the dry-cool Montane Spruce biogeoclimatic subzone in the Rocky Mountains, both tree swallows and mountain bluebirds were shown to be limited by the numbers of nesting sites, with nesting populations of both species increasing as nest boxes were added to clearcut areas (Holt and Martin 1997). Both species avoided nesting at the edge of clearcuts adjacent to continuous forest in that study, just as they did at Donna Creek in 1995 and 1996. This proximal avoidance to forested habitats could be due to the presence of mammalian nest predators such as red squirrels. For tree swallows and mountain bluebirds, stubs and/or tree islands are two effective options for mitigating the negative effects of clearcutting on the nesting habitat that would have been available in early seral habitats following wildfires. However, to be effective for these 2 species, it would appear that tree islands should be small enough so that they are ineffective habitat for potential mammalian predators such as red squirrels. Provision of nest boxes within clearcut areas would be another possible method of benefiting tree swallows and mountain bluebirds.

5.4.3 Northern Flickers

Only one northern flicker nest was found in one tree island at Donna Creek in 1996, and none were found in 1995. No northern flickers were suspected to be nesting in the experimental units in 1993 (Gyug and Summers 1995). Northern flickers are weaker excavators than the *Picoides* woodpeckers, and hence preferring to nest in more decayed trees or snags (Keisker 1986) and in dead trees more often than live trees (Moore 1995, Cannings et al. 1987). They will very often reuse old nesting holes in British Columbia (Cannings et al. 1987, Harris 2001). In Harris' (2001) 10-year stub study, northern flickers were one of the most common nesting species in stubs in a clearcut/partial cut, yet not one flicker had apparently excavated a new nesting hole in the entire 10-year period, instead always reusing old nest holes. Northern flickers will forage for insects on stubs (Bennett 1994) but primarily eat ground-dwelling ants and other ground-dwelling insects (Moore 1995). Therefore, northern flickers are not as dependent on insects in stubs as a food source like black-backed woodpeckers, and may colonize clearcut areas for much longer periods than black-backed woodpeckers would be expected to, as long as some nesting opportunities are available.

Northern flicker pairs vigourously defend the area around the nest, establishing a minimum conspecific inter-nest spacing of about 70 m (Moore 1995). However, nests can be much closer since the nesting pair are very quiet while incubating and brooding, and other pairs may establish nests during that period as close as 20 m to another nest. This leads to a bimodal distribution of nest starting dates, higher nest densities and a protracted breeding season (Kilham 1973). While densities of northern flickers were very low at Donna Creek in 1995-1996, there may be higher densities there in the future.

5.4.4 Other Species

As the newly planted trees on the Donna Creek experimental units begin to grow around the stubs and tree islands, and the sapwood of the stubs continues to decay and soften, weak cavity excavators such as boreal chickadees and red-breasted nuthatches may become more common in the experimental units, whereas they generally avoided them from 1993 (Gyug and Summers 1995) to 1996 (Gyug 1997). In southern British Columbia, mountain chickadees established breeding territories in a 25-year old regenerating clearcut, the clearcut area was without stubs but did have taller stumps resulting from winter hand-falling and had some short snags and small cull trees that remained standing (Gyug and Bennett 1995). These features provided enough cavity nesting opportunities that mountain chickadees could use the clearcut, but only after regenerating trees had reached 4 to 5-m height. However, boreal chickadees, brown creepers, red-breasted nuthatches and several woodpeckers did not breed in that particular clearcut, although each of them did establish nests in an adjacent 25-year old regenerating clearcut that contained 0.9-ha tree islands (Gyug and Bennett 1995). It remains to future surveys at Donna Creek to examine whether tree islands alone, stubs alone or the combination of tree islands and stubs is more effective at mitigating the long-term habitat losses for these other cavity-nesting species that largely do not use the area shortly after timber harvesting has occurred.

Tree islands that averaged only 0.25 ha in size, as in the Donna Creek study, were too small to benefit red-breasted nuthatches (see Discussion in Gyug 1997). For red-breasted nuthatches, Gyug and Bennett (1995) suggest tree islands need to be at least 1.5 ha in size or, if smaller, the tree islands need to be linked together with other islands or continuous forest into one territory.

5.5 Stub Densities and Tree-island Sizes

Since only a single dispersed stub density was used at Donna Creek (5-10 stubs/ha) and only one tree-island size (around 0.25 ha), it is not possible to examine the effects of stub density or tree-island size on cavity nesting birds since there is no variation in these parameters. However, Bennett (1994) did find that densities of 30 stubs/ha, compared to 3 and 10 stubs/ha, were preferred for both feeding and nesting by cavity-nesting birds, so the density of stubs may be an important factor. Harris (2001), however, found a fairly sizeable number of cavity nests were used each year (average 8.6 cavity nests/yr) in a 10-year study where a density of only 1.3 stubs/ha were present in a clearcut-partial cut harvested area.

Different cavity-nesting species will have different requirements for suitable tree-island sizes, and these have been discussed separately above for each species or group to which this applies. However, in general, Schieck and Hobson (2000) found that 2 years after a fire small tree islands (considerably less than 1.0 ha) were dominated by species that nest and forage in large snags, but in clearcuts that had small tree islands were dominated by warblers and sparrows. Seip and Parker (1997) found that bird communities in tree islands >1.0 ha were quite similar to those of old forests. At Donna Creek, the effects of small residual tree islands (about 0.25 ha) in cutblocks, along with stubs in the adjacent clearcut area, appeared to allow warblers and sparrows to still be common rather than forest birds but also retained some of the woodpecker species found in the old forest, and provided habitat for black-backed woodpeckers that would otherwise have been absent.

5.6 Longer term Effects

The value of stubs and tree islands to cavity-nesting birds is likely to be both on the short term and on the long term. There are definite advantages to retaining both stubs and tree islands to the cavity-nesters that use early seral stages in the forest successional series as previously noted. However, the regenerating trees that are projected to be harvested in the future on a 100-120 year rotation in the Donna Creek area will only just be reaching the sizes that will be of use to cavity nesting birds (>27 cm DBH) when they will be harvested. These trees will also be harvested before the heart rots necessary to make trees suitable for cavity excavation have set in. Imbeau et al. (2001) believed that in mitigating the effects of clearcutting "the continuous availability of forest snags is almost always overlooked." Even if the stubs may rot and fall over in the medium term (15-30 years), the snags and live trees in the tree islands will still provide nesting spots for cavity nesting

birds while the younger forest is growing up around them. Therefore, using both stubs and tree islands to mitigate the effects of clearcutting on cavity nesting birds is most likely the best strategy.

Since there will be no cavity-nesting data for the sites between 1996 and the next visit, if any new cavities are found in the stubs, snags or live trees, it will not be possible to determine which species excavated the cavities. They could be made by the stronger primary excavators, the *Picoides* woodpeckers, or by weaker primary excavators such as northern flickers, chickadees or nuthatches. Cavities excavated by chickadees and nuthatches tend to have smaller entrance diameters than the woodpeckers, but since woodpeckers (particularly flickers) may enlarge the entrances to existing cavities, it will never be possible to know which species first made a cavity, and at what stage of decay in a stub the cavity was excavated.

In addition, it is not possible to fully prejudge the exact intervals when there will be significant stub losses to fallover, or shifts in use by cavity-nesting species. The best hedge against missing significant events is to either collect data annually, or on relatively short intervals such as 5 years. For example, the recolonization of the harvested areas by red squirrels may be the impetus and cause for significant changes in cavity-nest use by bird species that use the cutblocks in early seral stages. However, without data collected at relatively short intervals, future researchers analyzing the data will not be able to accurately separate causes for changes in cavity-nesting species use of the areas.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 MITIGATING THE EFFECTS OF CLEARCUTTING

Stubs should be as large as possible for nesting, preferably over 27 cm DBH, and spruce and balsam should be preferred over lodgepole pine. However, stubs for woodpecker feeding are also important. These can be any size, but larger stubs are preferred, and spruce and balsam species are preferred over lodgepole pine.

For black-backed woodpeckers, stubs at densities of 5-10 stubs/ha in combination with tree islands of 0.25 ha form a good method to mitigate the effects of conversion of old forests to early seral habitats by clearcutting.

For three-toed woodpeckers, stubs at densities of 5-10 stubs/ha and/or tree islands of 0.25 ha are not sufficient methods, either alone or in combination, to mitigate the effects of

conversion of old forests to early seral habitats by clearcutting. The exception will be where tree islands and stubs are within about 50 m of continuous forest, and then they will be of some use.

For tree swallows, mountain bluebirds and American kestrels, stubs and/or tree islands are a good method to mitigate the effects of conversion of old forests to early seral habitats by clearcutting.

On the short term (1-4 years after timber harvest), stubs at densities of 5-10 stubs/ha and 0.25-ha tree islands are not effective mitigation methods of the effects of clearcutting on habitat loss for boreal chickadees, red-breasted nuthatches, brown creepers or winter wrens. These species appear to prefer older forests, and these mitigation methods cannot be used to make up for that loss of habitat. It remains to be seen at what seral stage these species may begin using the clearcut habitats, and if these methods are required as mitigation of the effects of clearcutting on lack of nesting opportunities in later seral stages.

6.2 Future Studies at Donna Creek

This study has only examined the short-term effects (1-4 years post timber harvest) on cavity nesting birds in the Donna Creek area. The cavity nest searches need to be repeated at intervals in the future to determine medium and long-term effects. Annual cavity-nester censuses inside the blocks are highly recommended at this point as the most efficient use of budget for this project.

Only annual counts would allow for the accurate estimation of age and the source (i.e, excavated by a bird, or other natural agent) of all new cavities in the stubs in the project. Since the decay characteristics of a very large number of stubs are known, then the decay characteristics of the stubs in which any new cavities are excavated would add valuable information to the types of stubs used for cavity excavation. Given the robust and unique study design, and the amount of effort dedicated to decay assessments and stub counts to date, spending relatively small amounts on annual cavity nest searches would appear to be justified.

Cavity-nesting birds in clearcuts are one of the easiest groups of birds to census, and the simplest method is through nest counts. This could be completed fairly efficiently (3 trips to the sites per year, with 2-3 days of census time per trip by a crew of 2 people). The data could be quickly entered into the existing spreadsheets, and briefly summarized

annually, using the tables and maps in this report as templates. Full reports and analyses could be done at perhaps 10-year intervals when complete stub counts and/or breeding bird point counts are redone, and the results reported within one of those reports.

If not done annually as recommended above, then cavity-nest censuses should be done for 2 consecutive years at pre-determined intervals (e.g., 5 or 10 years) over the life of the project. However, given the relatively small cost of the cavity-nest censuses, collecting this data annually would give the best return on investment in this project since the overall sample size of cavity nests in any given year is relatively low (about 15/year in or near the blocks). The only way to increase sample size for parameters such as types of stubs used for nesting to relate to decay class, tree species, etc, and to accurately delineate trends in numbers for each species, is through annual censuses.

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Appendix A. Location co-ordinates and characteristics of cavity nest-trees for nest-trees with active cavity nests in 1995 and 1996, Donna Creek Forestry/Biodiversity Project: Block, Unit, Tree Island, Stub number, UTM co-ordinates (Zone 10, NAD83, in m) and precision (GPS is to within 5-m, others are to within tree island, or to within about 100 m for values derived from sketch maps), Distance to forest (or into forest for nest-trees outside cutblocks), Distance to nearest tree island, Distance inside tree island, Tree species, DBH, Decay Class (DK), % bark remaining, Root condition, Heartwood (HW) and Sapwood (SW) decay classes, Tree defects, Stem height, Number of cavities, Bird species using nest in each year, and Cavity origin, position (by thirds: top, middle and bottom), height, entrance size and aspect. Data collected during 1996 nest plots.

Nest Plot No	Block	Unit	Island	Stub No.	Location and UTM			Dist. to forest (m)	Dist. to tree isl. (m)	Dist. into tree isl. (m)
					Precision	Easting	Northing			
In experimental cutblocks										
16NP?A	5516	SI	Isl 16-4		In Isl	423230	6164260	160	0	NR
16NP01	5516	SB		2075	GPS	422648	6164148	35	570	
16NP04	5516	SB		2036	GPS	423001	6163767	197	153	
16NP05	5516	TI	Isl 16-8		In Isl	423620	6163960	150	0	
16NP06	5516	SI		1702	GPS	423474	6164410	75	110	
16NP07	5516	SI	Isl 16-3		In Isl	423320	6164080	340	0	5
16NP07B	5516	SI	Isl 16-3		In Isl	423300	6164090	330	0	NR
16NP08	5516	SB		2028?	GPS	422946	6163811	164	221	
16NP10	5516	SB		1916?	GPS	422981	6164219	111	230	
16NP11	5516	SI		1845	GPS	423072	6164327	42	142	
46NP01	5546	SI	Isl 46-1		In Isl	419890	6166270	95	0	NR
46NP02	5546	SB		1068	GPS	420038	6166163	244	158	
46NP04	5546	TI	Isl 46-6	NN?	In Isl	420090	6166540	75	0	NR
47NP03	5547	TI	Isl 47-4		In Isl	418880	6167610	275	0	0
47NP05	5547	SI	Isl 47-6		In Isl	419140	6167420	280	0	0
47NP06	5547	SB		8	GPS	418580	6166940	256	583	
47NP07	5547	TI	Isl 47-1		In Isl	418700	6167720	100	0	0
47NP08	5547	SI	Isl 47-5	324	GPS	419313	6167571	135	0	0
47NP09	5547	TI	Isl 47-1	NN233-8?	In Isl	418670	6167740	100	0	0
In other areas								Dist. Into forest		
10NP?A	5510	Burn			Poor	"top of block"		?		
16NP?B	5516	For			Sketch	423460	6164490	5		
16NP?C	5516	For			Poor	W of SB unit		50		
16NP02	5516	For			Sketch	422900	6164350	?		
16NP03	5516	For			Sketch	423700	6164400	20		
16NP09	5516	For			Sketch	422670	6164210	10		
46NP?A	5546	For			Sketch	419650	6166360	0		
46NP03	5546	For			Sketch	419360	6166670	7.5		
46NP05	5546	OG			Sketch	419450	6166940	150		
46NP06	5546	For			Sketch	419740	6166210	40		
47NP01	5547	For			Sketch	418270	6167280	0		
47NP02	5547	For			Sketch	419500	6167400	5-10		
47NP04	5547	For			Sketch	418800	6166700	35		
49NP01	5549	For			Poor			0		
49NP02	5549	CC		NN471	GPS	415748	6169644	120 (dist to forest)		

Appendix A. (continued).

Nest Plot No	Stem type	Stem tree species	DBH (cm)	DK	% Bark	Root	Decay HW	Decay SW	Stem defects	Stem Ht (m)	No. of cavities
In experimental cutblocks											
16NP?A	Snag	balsam	35.0	4+						8-10	2
16NP01	Stub	spruce	35.5	4	>75	1	D	1	none	3.05	2
16NP04	Stub	balsam	27.0	5	50-75	1	3	1	heartrot present	4.32	1
16NP05	Snag	pine	30.6	3	>75	1	3	2	heartrot present	17	1
16NP06	Stub	balsam	35.3	5	>75	2	D	2		3.76	1
16NP07	Snag	balsam	42.7	5	50-75	2	D	2	burn scars	12	1
16NP07B	Live	balsam	59.5	2	>75	1		1	broken top	25	1
16NP08	Stub	balsam	48.2	4	50-75	2	D	2	spiral crack in stub serves as entrance		1
16NP10	Stub	spruce	26.6	4	>75	1	D	2	heartrot present	3	1
16NP11	Stub	balsam	35.6	6	<50					3.97	1
46NP01	Live	balsam	27.2	2	>75	1	2	1	1 cm of core heartrot	18.2	1
46NP02	Stub	balsam	39.0	6	>75	3	D	3	broken top	3.5	5
46NP04	Stub	spruce	37.9	3	>75	1	D	1	extensive heartrot	3	1
47NP03	Snag	balsam	37.0	4	>75	1	D	1		16.1	2
47NP05	Snag	balsam	33.1	3	>75	1	3	1		14	1
47NP06	Stub	balsam	39.3	6	<50	D	D	3	conks, decay fungi at base	4.3	1
47NP07	Snag	balsam	38.3	5	>75	2	D	2	broken top	8	1
47NP08	Stub	spruce	48.1	4	>75	1	D	2		3	1
47NP09	Stub	spruce	48.2	4	>75	1	D	2	extensive heartrot, conks	4.5	2
In other areas											
10NP?A	Snag	unk							burned		
16NP?B	Live	spruce	28.0	1 - 2						12	1
16NP?C	Snag	balsam	50.0	4+						10	1
16NP02	Snag	pine	31.2	3	>75	1	3	1	heartrot present	23.5	2
16NP03	Snag	balsam	30.3	3	>75	D	3	2	conks, heartrot	*16.79*	1
16NP09	Snag	spruce	36.2	3	>75	1	3	3	broken top	4	1
46NP?A	Live	spruce	40.0	1 - 2						20-25	2
46NP03	Live	spruce	46.2	2	>75	1	2	1	heartrot present	36	1
46NP05	Snag	spruce	40.1	4	>75	1	D	1	top broken, heartrot	12	1
46NP06	Snag	spruce	49.3	4	>75	2	D	2	decay fungi on base	20	1
47NP01	Snag	pine	38.4	3	>75	1	1	1	heartrot present	25	1
47NP02	Live	spruce	35.8	2	>75	1	2	1	broken top	25	1
47NP04	Snag	pine	39.8	3	>75	1	3	1	heartrot present	10	1
49NP01	Live	spruce	49.0	2	>75	1	2	1	broken top	10	1
49NP02	Stub	balsam	44.9	7	<50	D	D	3	Conks	3	2

Appendix A. (continued).

Nest Plot No	Bird Species [a]		Active Cavities	1995-1996 Active Cavity Data					
	1995	1996		Origin	Position	Ht. (m)	Age (yrs)	Entrance size (cm)	Entrance aspect
In experimental cutblocks									
16NP?A	RBNU			bird made	top		3-5		
16NP01	TTWO		2 different cavities	bird made	top	2.5	new	8.2	260
	TRSW			bird made	top	2.8	2+	5.5	80
16NP04	BBWO TRSW	BBWO TRSW		bird made	middle	1.77	New 1995	4.9	225
16NP05	BBWO	MOBL	same	bird made	middle	5.07	1+	4.9	
16NP06	MOBL	MOBL	same	bird made	middle	1.98	1-2	7.5	300
16NP07	MOBL	NOFL	same	natural	top	11.5	5+		
16NP07B		MOBL		natural	top		3		
16NP08	MOBL			natural	top		2-3		
16NP10	BBWO	BBWO	same	bird made	middle	1.8	1+		
16NP11		TRSW		bird made	top	3.55	10+	8.0	315
46NP01	BBWO			bird made	middle	8.6	new	5.3	10
46NP02	MOBL			bird made	top		5+		100
46NP04	TTWO			bird made	middle		new		350
47NP03	HAWO	TRSW	same	bird made	top	15.6	new 1995		238
47NP05	BBWO	BBWO	same	bird made	bottom		new 1995		
47NP06	MOBL	MOBL	same	bird made	top	3.77	4+	5.4	206
47NP07	TRSW			bird made	top		3+		
47NP08		TTWO		bird made	top	3.71	new	[illegible]	
47NP09	TTWO			bird made	top	3.79	3+	5.5	225
		TTWO	new	bird made	top	3	new 1996	4.1	
In other areas									
10NP?A	MOBL			bird made					
16NP?B	TTWO			bird made	middle		new		
16NP?C		RBNU		bird made	middle		new		
16NP02	TTWO			bird made	bottom	6.9		4.8	
16NP03	TTWO			bird made	bottom	2.9	new	5.1	225
16NP09		TTWO		bird made	middle		new		
46NP?A	RBNU				middle	12	1-2		
46NP03	TTWO				bottom	7-8	1-2		97
46NP05		TTWO		bird made	middle		new		
46NP06		TTWO		bird made	bottom		new	4.2	
47NP01	TTWO			bird made	middle	12	new		135
47NP02	TTWO			bird made	middle	11	new		42
47NP04		TTWO		bird made	middle	4.8	new	4.0	
49NP01	TTWO			bird made	top		new		
49NP02	TRSW	MOBL	same		top	2.9	3-5	4.9	

[a] BBWO = black-backed woodpecker, HAWO = hairy woodpecker, MOBL = mountain bluebird, NOFL = northern flicker, RBNU = red-breasted nuthatch, TRSW = tree swallow, TTWO = three-toed woodpecker.

Appendix B. Location co-ordinates and characteristics of numbered stubs with cavities that were not used for nesting in 1995 or 1996, Donna Creek Forestry/Biodiversity Project: Block number, Unit, Tree Island, UTM co-ordinates (Zone 10, NAD83, in m), Tree species, diameter at breast height (DBH; in cm), Decay Class (DK), % bark remaining, Root condition, Heartwood (HW) and Sapwood (SW) decay classes, Tree defects, Number of cavities, Cavity height, Cavity direction, and Entrance size. Data collected during 1996 stub decay assessments.

	Location Information						Stub stem information								Cavity Information		
	Block	Unit	Island	UTM easting	UTM northing	Tree species	DBH (cm)	DK	% bark	Root	Decay HW	Decay SW	Tree defects	N	Ht (m)	Dir.	Entrance size [a] (cm)
Stub No																	
392	5547	SI		419517	6167581	balsam	34.3	3	<50	1	2	1	butt rot, FB scars, cracks	4	All ~3m	3-NE 1-S	7x9,4x4,4x6 6
1184	5546	SI	Isl 46-2	419734	6166437	balsam	28.1	4	50-75	2	1,2	1,2	-	1	2.5	E	3
1350	5546	SI		419578	6166824	balsam	49	5	<50	2	D	2	cracks, conks on SE side, butt rot	1	2.5	-	10x15
1759	5516	SI		423166	6164387	balsam	62	4	>75	2	1,2	2	-	1	2	-	8
1764	5516	SI		423156	6164306	balsam	48	4	>75	D	2	1	crack, butt rot, slight lean	1	3	-	8
1778	5516	SI		423231	6164122	balsam	21	4	50-75	2	2	2	-	1	3	W	7
1839	5516	SI		423134	6164351	balsam	46	-	-	-	-	-	-	-	-	-	-
2020	5516	SB		422923	6163842	spruce	65.5	5	>75	3	3	2	FB scars	1	3	-	5x7
2068	5516	SB		422728	6164170	balsam	31	4	50-75	2	2	1,2	FB scar, canker, butt rot starting	1	2.5	W	6

[a] Where entrance was circular, only the diameter is given.